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ABSTRACT

This report presents the results of two field-based experimental studies to determine the effects of questioning techniques on student achievement and attitudes. The first study was done to determine what student learning outcomes are affected by teachers' use of probing and redirection techniques in classroom discussions. Another purpose of the experiment was to determine the relative effect on student learning of teachers' questions delivered in both oral and written formats. The second study was conducted to determine what student learning outcomes are affected by variations in teachers' use of higher cognitive questions. These questions require the student to state predictions, solutions, explanations or opinions, expanding on information presented in the curriculum and interpreting it in his own way. This experiment was designed to test the belief that use of higher cognitive questions is important for developing students' ability to think. The finding of both studies was that discussion following critical viewing and/or reading of curriculum materials was effective in promoting student achievement. Writing responses to questions appeared to develop knowledge acquisition as effectively as participation in discussion. However, written exercises seemed less effective for improving higher cognitive response ability than oral discussion in which the students' responses are probed and redirected by the teacher. The methodology of the experiment is described in detail, and five appendixes list the statistical results of the two studies. (JD)

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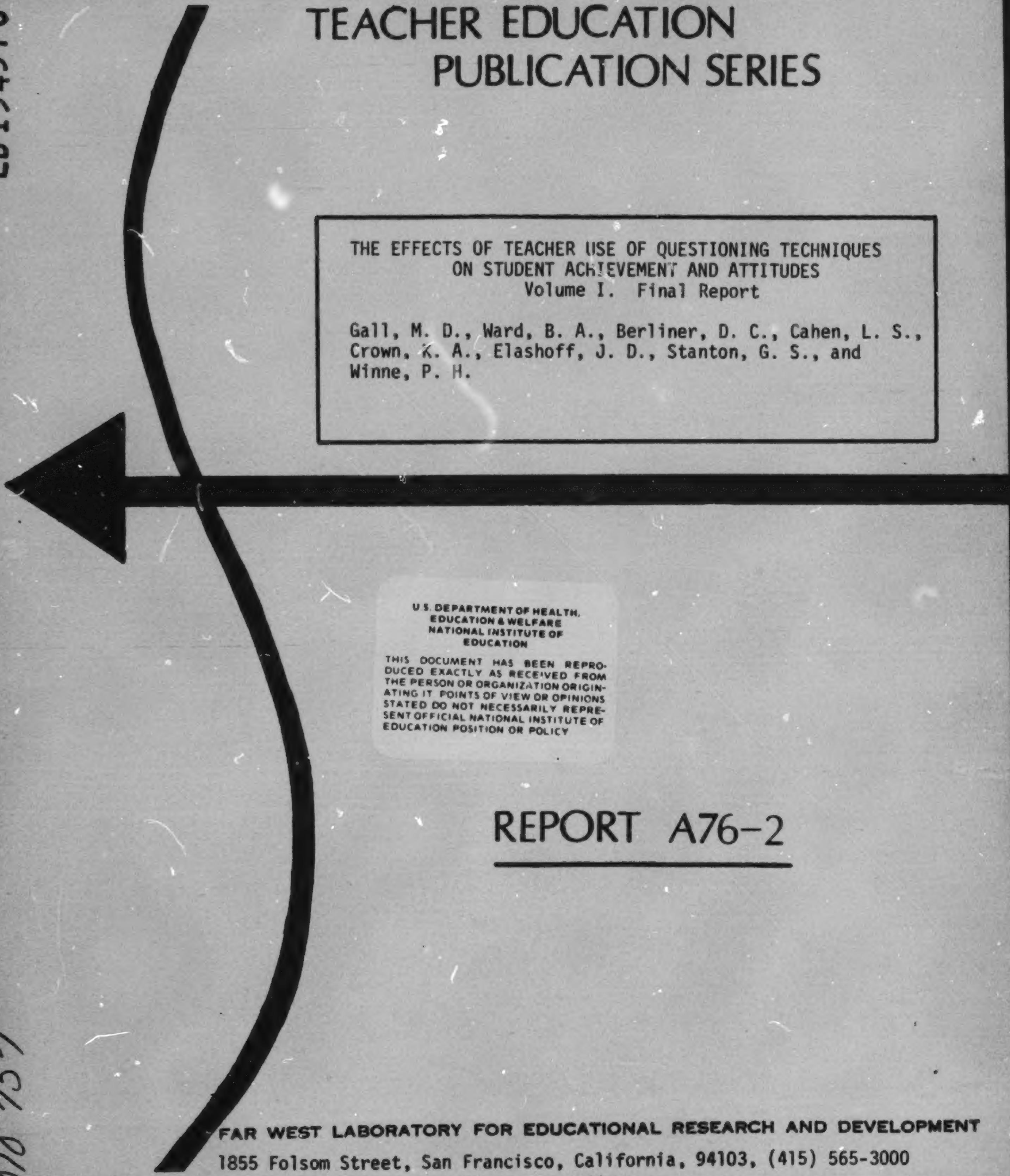

THE EFFECTS OF TEACHER USE OF QUESTIONING TECHNIQUES ON STUDENT ACHIEVEMENT AND ATTITUDES
Volume I. Final Report

Gall, M. D., Ward, B. A., Berliner, D. C., Cahen, L. S., Crown, K. A., Elashoff, J. D., Stanton, G. S., and Winne, P. H.

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Volume I. Final Report

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March 1976

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ACKNOWLEDGEMENTS

The experiments reported in the four volumes of this report represent an ambitious, large-scale attempt to determine the effects of teacher questioning techniques on student achievement and attitudes. Nine treatments were administered to approximately 700 students distributed across 24 classrooms in two school districts. Eleven achievement tests and attitude scales, measuring 32 different variables, were developed and administered to each student. Data collection and experimentation extended over a period of three months.

This type of large-scale research requires the cooperation and talents of many people, whom we wish to acknowledge here. First, we express our appreciation to the assistant superintendents of Novato and San Lorenzo School Districts located in the San Francisco Bay Area. They supported our research goals and recruited participants. We also are endebted to the school principals and teachers in these districts who permitted us to work with their students. They gave excellent cooperation in all phases of the project. Our experimenter-teachers found it rewarding to work with the students in these districts. The students were well-motivated, co-operative, and understood the requirements of the experimental procedures. The school district participants are not identified by name in order to preserve confidentiality of data source.

Some features of the research design were based on earlier work done by the senior author in the field of classroom questioning techniques. The design was further developed in collaboration with Kenneth Crown and with Philip Winne of the Stanford Center for Research and Development in Teaching.

Dr. Winne was involved in all phases of the project, from inception to completion, and is responsible for much of whatever scientific rigor it may possess. David Berliner and Beatrice Ward made major contributions in the conceptualization of the research variables to be investigated and provided administrative support throughout the project. Dr. Ward also assisted with the writing of this report. Dr. Berliner was especially helpful in recruiting staff and consultants with specialized research skills. Janet Elashoff of the University of California at Los Angeles considerably improved the early versions of the research by recasting it in the form of a Latin square design. Others who reviewed and contributed to the design were Robert Heath of Nomos Institute, Stephen Klein of Systems Development Corporation, Leonard Marascuilo of the University of California at Berkeley, Barak Rosenshine of the University of Illinois, James Shaver of Utah State University and Samuel Messick of Educational Testing Service.

The ecology curriculum was developed primarily by Kenneth Crown, Lorraine Thorn, Beatrice Ward, and the senior author. Consultant support was provided by Fred Rosenau of the Far West Laboratory, Chester Lawson of the Lawrence Hall of Science, and Frank Ryan of the University of California at Riverside. Peggy Cling of Daniel Webster Elementary School in San Francisco and Peter Baldo of Castro Valley Elementary School graciously permitted the staff to pilot-test the materials in their classrooms.

The development of the achievement and attitudinal measures was the responsibility of the senior author, with substantial assistance provided by Robert Heath and Mark Nielsen of the Nomos Institute. Gerrie Smith carried out the item analyses needed to refine the measures. Kenneth Crown pilot-tested the measures and participated in their revision.

Marilyn Madsen was responsible for recruitment of the participating schools. She, along with Kenneth Crown and Lorraine Thorn, coordinated data collection and administration of the treatments. They deserve credit for accomplishing a high level of treatment fidelity, relatively complete data collection, and cooperation of all participants in this study.

Twelve teachers, selected and trained by Lorraine Thorn and Kenneth Crown, administered the treatments. Their professional competence, enthusiasm, and cooperation was essential to the success of the study. We wish to acknowledge each of them--Sandra Cohen, Nancy Cook, Margaret Cross, Maisie Dea, Esther Kay Homsey, Martha Karatz, Constance McBrier, Patricia Mulford, James Nettleton, Wilma Parker, Diane Racine, and Norma Shultz.

The data analysis phase of the study was directed by Leonard Cahen and the senior author. Philip Winne and George Stanton of the Stanford Center for Research and Development in Teaching and Janet Elashoff provided statistical consultation. In addition, George Stanton was responsible for data management and all the computer work used to generate the analyses reported in this volume and in Volume IV. His heroic dedication to these tasks was essential to the success of this phase of the study.

Another major effort in this phase was the scoring of the subjective measures of student achievement which were administered in the two experiments. A team of five raters performed this task with skill and patience: Linda Davis, Audrey Ferber, Keith Jones, Carol Rice, and William Sees. Keith Jones and Carol Rice were particularly helpful in collaborating with the senior author to develop and refine the rating procedures. Dan Johnson was responsible for developing rating procedures used to analyze audiotapes of treatment sessions for fidelity of treatment. William Sees also participated in this project.

The writing of the final report (Volume I) is primarily the work of the senior author, Beatrice Ward and Philip Winne. Other contributors were Janet Elashoff, who wrote the section on analysis of variance procedures; Robert Heath who described the research design; and Kenneth Crown, who wrote the description of the curriculum and treatment procedures. It should be emphasized, though, that the report reflects the ideas and contributions of the entire project staff.

The authors were assisted in report preparation by Carol Rice and Dan Johnson, who organized the various sections which appear in the four volumes, performed supplementary data analyses, and prepared tables and figures.

The research staff was fortunate to enjoy the exceptional talents of Ursula Hoffman, the project secretary. We are endebted to her for helping to maintain staff morale and for keeping track of ever-multiplying details. Also, she designed, typed, and organized the production of all materials used in the study. We wish to acknowledge, too, Carolyn Amable and Janete Weyrick, who provided secretarial support and Marion Lentz who provided additional editorial and proofreading support.

Meredith D. Gall
March 1976

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ABSTRACT

The Effects of Teacher Use of Questioning Techniques on Student Achievement and Attitudes

Introduction

This report presents the results of two field-based experimental studies of teaching conducted by the staff of the Effective Teacher Education Program (ETEP) at the Far West Laboratory for Educational Research and Development. ETEP grew out of the Laboratory's earlier work in developing a series of skill-training packages for teachers called Minicourses. Relatively little is known about the effect of the teaching skills in the Minicourses on student learning. Therefore, as part of its research effort, ETEP initiated two studies to determine the effects of the questioning techniques presented in Minicourse 1 (Effective Questioning--Elementary Level) and Minicourse 9 (Higher Cognitive Questioning) on student achievement and attitudes.

Study I

Purpose

This experimental study was done to determine what student learning outcomes are affected by teachers' use of probing and redirection techniques in classroom discussions. Probing occurs when the teacher seeks to improve the quality of a student's initial answer to a question by asking a follow-up, that is, a "probing," question. Redirection occurs when the teacher calls upon more than one student to respond to a question already asked of another student. It was hypothesized that probing and redirection techniques would promote learning since they provide students with practice in organizing their facts and ideas into overt responses.

Another purpose of the experiment was to determine the relative effect on student learning of teachers' questions delivered in oral format (discussion) compared with the same questions presented and answered in written format.

Review of Literature

In his review of research on teacher effectiveness, Rosenshine (1971) identified three correlational studies in which the teacher's use of probing and redirection following a student's initial answer to a question was related to student achievement measures. In two of these studies the specific behaviors of probing and redirection were not correlated directly with student achievement; instead, the factors on which the teacher behaviors were loaded were correlated with student achievement.

In the third study (Wright and Nuthall, 1970) frequency of redirection had a high positive correlation (r=.54) with regressed student achievement scores on a fact-recall test. The technique of asking a follow-up question at the same or higher cognitive level (i.e., probing questions) as the initial question was only slightly correlated with student achievement (r=.20). The present study differs from the Wright and Nuthall study in that it investigates probing and redirection techniques experimentally, and a variety of learning outcomes are analyzed.

Treatments

Five experimental treatments were utilized in Study I. The common basis for the five treatments was a specially designed ecology curriculum. The curriculum included ten lessons, each requiring an hour of class time, and taught at the rate of one per day. The curriculum materials were provided to all students, irrespective of treatment assignment, at the beginning of the class hour. Following viewing and/or reading of materials, students formed into their assigned treatment groups. The five treatments are as follows:

> *Probing and Redirection Treatment.* Specially trained teachers (called "ecology teachers" here) conducted "scripted one for each lesson. These discussions were scripted by the researchers to insure uniformity of treatment across ecology teachers and to equate opportunity to learn the curriculum content across treatment groups. Each discussion consisted of sixteen questions, eight of them at the knowledge and comprehension levels of Bloom's taxonomy (1956); the other eight questions were at the analysis, synthesis, and evaluation levels of the taxonomy. Since appropriate use of probing and redirection techniques depends upon a student's initial response to a question, this aspect of the discussions could not be scripted precisely. Instead, the ecology teachers were given guidelines concerning when and how often to use each technique.
>
> *No Probing and Redirection Treatment.* This treatment was identical to the above, except that the ecology teachers were instructed not to use probing and redirection techniques. Instead, they were instructed to accept the student's first response to each question, and when appropriate give a model response. This treatment required approximately ten less minutes of class time than did the Probing and Redirection treatment.
>
> *Filler Activity Treatment.* This treatment was identical to the No Probing and Redirection Treatment, except that the ecology teachers were instructed to engage in ten minutes of filler activity following completion of each discussion. If the Probing and Redirection Treatment was found to be superior to the No Probing and Redirection Treatment, it could be argued that the contributing factor was the ten extra minutes of "time on task" rather than teachers' use of these techniques. The Filler Activity Treatment was designed to assess the effect of "time on task," independent of probing and redirection, on student achievement.

Art Activity Treatment. The students in this treatment participated in nine sessions of ecology-related art activities. The ecology teachers were instructed not to ask any curriculum-related questions during these lessons. The time for each art activity lesson was approximately equal to that of the Probing and Redirection Treatment.

Written Exercise Treatment. This treatment included the same questions as in the discussion treatments. However, students were presented the questions in booklet form and asked to write the answers in the space provided. The time for each written exercise lesson was approximately equal to that of the Probing and Redirection Treatment. The ecology teacher was instructed not to ask ecology-related questions, but instead only to manage the students' work.

Audiotapes of the three discussion treatments were made for two different lessons. Analysis of these audiotapes indicated high fidelity of treatment for these treatments. Observations of the Art Activity and Written Exercise treatments also indicated that ecology teachers adhered closely to the requirements of these treatments.

Student Sample

Study I was conducted in the San Lorenzo Unified School District, San Lorenzo, California. A total of twelve sixth-grade teachers, two in each of six schools, volunteered for their students to participate in the study. A total of 336 students from these classes were assigned to the five experimental treatments.

Experimental Design

Four of the treatments--Probing and Redirection, No Probing and Redirection, Filler Activity, and Art Activity--were manipulated in a Latin square design. The Written Exercise Treatment was administered as a side-experiment outside the Latin square design. Multi-stage randomization procedures were used to assign schools and sixth-grade classrooms to Latin square blocks, teachers to Latin square blocks, treatments to teachers, and students to treatments. Basically, this procedure resulted in twelve replications of each treatment. Each replication involved a different group of six students and a different ecology teacher. The fifth treatment (Written Exercise Treatment) was composed of left-over students in each classroom after 24 of their classmates had been randomly assigned to the discussion and art activity treatments.

Measures

Outcome measures were administered immediately before (pre), immediately after (post), or two weeks after (delayed) the treatments. The measures included:

Verbal Ability. Student's scores of verbal ability from the Comprehensive Tests of Basic Skills (CTBS, Form Q-Level 2) were made available by the participating school districts. Where appropriate, these scores were used to adjust students' post and/or delayed scores on the other outcome measures.

Information Test. This multiple-choice test was administered three times to each student: pre, post, and delayed. It was designed to measure students' acquisition of factual information in the ecology curriculum. The test consists of two subscales to measure intentional and incidental learning. Intentional Scale 1 contains ten items measuring students' ability to recall information covered in the discussion treatments and the Written Exercise Treatment. Incidental Scale 1 consists of 17 items testing recall of information presented in the curriculum materials but not in any of the treatment variations.

Oral Test. This individually administered test consists of six higher-cognitive questions which students answered orally. It was given pre and post treatment to all students, and was designed to measure students' ability to give plausible, reasoned oral responses to higher cognitive questions about the ecology curriculum. Since the nature of discussion is to elicit oral responses, it was thought that this test might be particularly sensitive to differences between the treatments; for example, in the comparison of the discussion treatments with the Written Exercise Treatment. This test, like the Essay Test and Transfer Test described below, is scored on two scales: content (the number of plausible solutions, predictions, explanations, etc., in response to each question) and Logical Extension (the number of rationales and if...then extensions in response to each question).

Essay Test. This test, administered pre and post treatment, consists of twelve higher cognitive questions for which students are to write brief essay answers. Similar to the Oral Test, the content of the Essay Test questions refers to the ecology curriculum.

Transfer Test. This test, administered two weeks after completion of the treatments, consists of nine higher-cognitive questions for which students are to write brief essay answers. The purpose of this test was to determine whether higher cognitive response skills learned in the treatments would transfer to a new, unstudied curriculum topic--the problem of human population explosion.

Word Association Scale. This set of scales, administered pre and post treatment, measures students' attitudes toward the major topics taught in the ecology curriculum. The measure consists of six semantic differential scales, each measuring students' attitudes toward a specific ecological topic through the use of ten bi-polar adjectives from Osgood's evaluative factor.

Gall-Crown Discussion Attitude Scale. This measure, adminstered pre and delayed treatment, consists of two Likert-type subscales: one of nineteen items measuring students' attitude toward class discussions and one of eleven items measuring students' attitudes toward teacher use of higher cognitive questions.

A measure of attendance was obtained by counting the number of treatment sessions (possible range, 0-10) at which each student was present. Several instruments were administered post treatment to determine students' attitude toward various aspects of the treatment experience. Also, a question-generating test was administered pre and post treatment to measure students' ability to generate questions on curriculum-relevant topics. Findings based on use of these instruments are presented in the full report.

Data Analysis Plan

The data in the Latin square design were examined by analysis of variance methods. Each of the main factors--discussion treatment, classrooms, teachers, and squares--was considered as a fixed effect in partitioning the total variance into main effects for treatments, classrooms within squares, teachers within squares, squares, a treatment by square interaction, and a residual (error) term. Each dependent variable was examined for the possibility of adjusting for pre-experimental differences before performing the analyses of variance.

In addition to examining the data for overall treatment differences, several a priori questions pertaining to differences between treatment groups were of interest. The following planned comparisons of treatment differences were examined: (a) Probing and Redirection versus No Probing and Redirection; (b) No Probing and Redirection versus Filler Activity; (c) the discussion treatments as a whole (i.e., Probing and Redirection, No Probing and Redirection, Filler Activity) versus Art Activity.

The analysis of variance design does not permit significance-testing comparison of the Written Exercise Treatment with the other four treatments. However, a basis for deciding whether the Written Exercise Treatment means on dependent measures were reliably different from other treatment means was provided by computing 95 percent confidence limits for each of the Written Exercise Treatment means. The "test" is thus to determine whether any of the discussion or act activity means fall above or below these limits.

Findings

The results of the primary data analyses are summarized in Table 1 (measures of ability, achievement, and attendance) and Table 2 (attitude scales).

The leftmost column lists the names of the dependent variables. Each row of the table corresponding to the variable names presents information pertaining to that variable only.

TABLE 1

Analysis of Variance Summary for Study I Measures of Ability, Achievement, and Attendance

DEPENDENT VARIABLE	ADJUSTING VARIABLE	MSerror df=17	F VALUES AND ω^2 FOR ANALYSIS OF VARIANCE EFFECTS										TREATMENT MEANS						PLANNED COMPARISONS		
			Treatment		Class		Teacher		Square		Treatment by Square		Probe & Re-direct	No Prb & Re-direct	Filler Activ.	Art Activ. I	Writ. Exerc.	95% Limits for Treatment 5	Treatments 1 vs 2	Treatments 2 vs 3	Treatments 1,2,3 vs 4
			$F_{3,17}$	ω^2	$F_{9,17}$	ω^2	$F_{9,17}$	ω^2	$F_{2,17}$	ω^2	$F_{6,17}$	ω^2	(1)	(2)	(3)	(4)	(5)		$F_{1,17}$	$F_{1,17}$	$F_{1,17}$
Number of Sessions Attended		0.55	1.74	0.06[a]	0.48	0.12	0.68	0.07	0.56	0.02	0.88	0.13	9.03	9.35	8.78	9.40[b]	9.23	8.84 - 9.62	1.11	3.45	1.73
CTBS[c] - Total Reading		61.14	2.31	0.06	1.82	0.12	0.93	0.01	3.36	0.07	1.13	0.01	58.89	54.42	53.81	50.16	57.45	14.65 -100.25	1.96	0.04	3.89
Ecology Information Test:																					
Intentional Scale I, post	total rdng.	0.85	5.04*	0.20	2.53*	0.22	0.46	0.00	0.35	0.00	0.26	0.00	5.79	6.00	6.16	4.73	6.20	5.61 - 6.80	0.30	0.18	14.16*
Intentional Scale I, delay		1.12	6.90*	0.19	3.19*	0.21	1.09	0.01	2.44	0.03	1.73	0.05	5.69	5.13	5.73	3.89	5.15	4.37 - 5.93	1.71	1.97	18.25*
Incidental Scale I, post		2.52	3.07	0.12	1.61	0.10	1.20	0.03	0.06	0.01	0.87	0.21	7.69	7.83	7.02	5.96	7.83	6.07 - 9.59	0.04	1.56	7.41*
Incidental Scale I, delay	total rdng.	2.46	1.06	0.00	2.38	0.25	0.21	0.00	0.61	0.00	0.69	0.00	7.00	6.89	6.40	5.93	7.08	5.36 - 8.80	0.03	0.60	2.90
Oral Test:																					
Content, post	pre	1.08	6.83*	0.30	0.64	0.00	0.94	0.00	0.62	0.00	0.74	0.00	8.41	8.14	7.47	6.55	7.62	6.86 - 8.38	0.40	2.54	15.24*
Logical Extension, post		1.49	3.05	0.10	1.55	0.08	1.27	0.04	2.12	0.04	0.75	0.00	2.59	3.33	2.92	2.09	2.79	1.75 - 3.83	0.28	0.64	7.35*
Essay Test:																					
Content, post	pre	1.92	3.13	0.08	3.24*	0.22	0.37	0.03	2.10	0.16	0.53	0.03	10.72	10.58	9.86	9.09	9.79	8.45 - 11.13	0.06	1.62	6.72*
Logical Extension, post		0.28	5.37*	0.13	5.67*	0.41	0.75	0.00	0.16	0.00	1.58	0.03	1.79	1.58	1.40	0.91	1.46	1.26 - 1.66	1.02	0.66	12.78*
Transfer Test:																					
Content, delay	essay pre	1.71	3.42*	0.07	3.27*	0.32	1.28	0.00	8.79*	0.10	1.43	0.09	8.15	8.09	6.85	6.93	6.80	5.60 - 8.00	0.01	5.39*	2.67
Logical Extension, delay		0.26	3.05	0.05	5.55*	0.35	1.41	0.03	11.58*	0.18	0.93	0.00	1.56	1.55	1.39	0.97	1.42	1.24 - 1.60	0.00	0.60	8.33*
Written Question Generating Test:																					
Non-pertinent Questions		0.12	5.12*	0.09	7.80*	0.42	1.69	0.04	9.65*	0.12	1.21	0.01	0.52	0.52	0.41	0.95	0.56	0.48 - 0.64	0.00	0.65	14.52*
Pertinent Questions	pre	44.69	1.05	0.00	5.62*	0.43	0.76	0.00	4.09*	0.06	1.84	0.05	12.41	10.97	11.94	11.38	13.33	-17.95 - 44.61	2.79	1.25	0.27
Specific Questions		8.69	3.17	0.06	3.62*	0.22	2.48	0.13	2.93*	0.07	2.98*	0.11	3.30	2.96	3.05	2.12	3.87	-2.21 - 9.95	0.79	0.05	8.54*
Request for Rationale		0.13	2.05	0.08	30.05*	0.02	5.32*	0.04	9.80*	0.31	6.99*	0.18	0.78	0.57	0.51	0.25	0.70	0.61 - 0.79	1.79	0.16	7.50*
Quality Rating	pre	0.68	3.23*	0.07	4.61*	0.32	0.60	0.00	6.09*	0.10	2.47*	0.00	3.04	3.08	2.86	2.79	3.08	2.60 - 3.56	0.19	4.43	4.76*
Oral Question Generating Test:																					
Non-pertinent Questions		0.06	3.38*	0.16	0.47	0.10	1.11	0.02	0.77	0.00	0.33	0.00	0.33	0.10	0.10	0.03	0.56	0.52 - 0.60	5.55*	0.00	2.90
Pertinent Questions		0.35	1.45	0.03	1.59	0.11	1.14	0.03	0.58	0.02	0.40	0.07	1.36	1.82	1.64	1.43	1.65	1.41 - 1.90	3.57	0.55	0.71
Quality Rating		0.10	2.13	0.07	1.54	0.11	0.78	0.00	0.82	0.00	0.77	0.00	0.80	1.00	0.96	1.14	0.95	0.88 - 1.02	2.37	0.11	3.75

*Significance at the .05 level. The .05 levels for F values with the following degrees of freedom are:
$F_{1,17}=4.45$ $F_{2,17}=3.59$ $F_{3,17}=3.20$ $F_{6,17}=2.70$ $F_{9,17}=2.49$

[a] ω^2 = proportion of total variance explained (omega squared). The missing cell in the Latin square design was estimated to compute the total sum of squares.

[b] Means for Art Activity Treatment I differ from the actual means because a missing cell value was estimated in the analysis of variance.

[c] CTBS = Comprehensive Tests of Basic Skills

TABLE 2

Analysis of Variance Summary for Attitude Scales in Study I

DEPENDENT VARIABLE	ADJUSTING VARIABLE	MS_{error} df=17	F VALUES AND ω^2 FOR ANALYSIS OF VARIANCE EFFECTS										TREATMENT MEANS						PLANNED COMPARISONS		
			Treatment		Class		Teacher		Square		Treatment by Square		Probe & Re-direct	No Prb & Re-direct	Filler Activ.	Art Activ. I	Writ. Exerc.	95% Limits for Treat-ment 5	Treat-ments 1 vs 2	Treat-ments 2 vs 3	Treatments 1,2,3 vs 4
			$F_{3,17}$	ω^2	$F_{9,17}$	ω^2	$F_{9,17}$	ω^2	$F_{2,17}$	ω^2	$F_{6,17}$	ω^2	(1)	(2)	(3)	(4)	(5)		$F_{1,17}$	$F_{1,17}$	$F_{1,17}$
Word Association Scale:	—																				
Balance of Nature	—	17.67	0.92	0.00[a]	2.11	0.17	2.33	0.20	1.93	0.03	1.90	0.09	55.62	57.61	57.66	55.52[b]	54.35	39.54 - 69.16	1.35	0.00	0.91
Ecology	—	21.16	1.15	0.01	2.12	0.25	1.47	0.11	0.11	0.00	0.48	0.00	58.41	61.38	61.13	61.34	60.48	48.11 - 72.85	2.50	0.02	0.40
Wolf	pre —	32.55	1.30	0.02	0.92	0.00	0.87	0.00	0.10	0.00	1.07	0.00	47.27	47.66	45.48	43.30	50.87	28.09 - 73.66	0.03	0.88	0.91
Air Pollution	—	10.59	1.14	0.00	1.44	0.09	0.45	0.00	0.14	0.00	0.93	0.00	60.29	59.36	58.29	58.05	58.23	50.82 - 65.64	0.50	0.64	1.14
Alligator	pre —	27.90	2.24	0.07	1.20	0.03	0.88	0.00	0.28	0.00	1.42	0.04	52.55	51.62	51.96	47.18	48.49	28.96 - 68.02	0.19	0.02	6.54*
Water Pollution	pre —	9.58	1.14	0.00	0.88	0.00	0.59	0.00	0.15	0.00	1.06	0.00	59.58	59.39	57.95	57.63	59.18	52.47 - 65.89	0.02	1.29	1.44
Gall-Crown Discus. Attitude Scale:	—																				
Att. toward Thought Questions	pre —	7.96	0.25	0.00	1.71	0.15	0.55	0.00	0.52	0.00	0.37	0.00	30.29	31.14	30.31	30.36	28.60	23.03 - 34.17	0.54	0.51	0.05
Attitude toward Discussion	pre —	8.39	1.32	0.01	5.38*	0.33	2.44	0.13	0.56	0.00	1.16	0.01	54.86	56.45	54.97	54.06	53.69	47.82 - 59.56	1.80	1.57	1.71
Ecology Unit Opinions Scale:	—																				
Attitude toward Peers	—	3.46	0.16	0.00	1.56	0.08	2.43	0.20	0.50	0.00	1.05	0.00	15.88	16.14	16.41	16.19	16.00	13.57 - 18.43	0.12	0.13	0.01
Attitude toward Teacher	—	10.74	1.53	0.02	3.80*	0.32	1.97	0.11	0.91	0.00	0.36	0.00	55.88	57.57	56.63	54.65	58.37	50.81 - 65.93	1.60	0.49	2.99
Attitude toward Curriculum	—	4.32	1.64	0.02	4.06*	0.29	1.87	0.08	6.18*	0.11	0.81	0.00	29.97	31.36	31.18	29.50	30.86	27.82 - 33.90	2.68	1.93	1.80
Ecology Discussion Attitude Scale:	—																				
Att. toward Thought Questions	—	3.83	2.10	0.01	4.10*	0.31	2.67*	0.16	1.41	0.00	0.74	0.00	31.56	33.20	32.27				4.16	3.42	
Attitude toward Discussion	GDAS – Disc pre —	4.54	3.64*	0.03	3.08*	0.16	6.12*	0.41	0.71	0.00	0.40	0.00	57.76	59.88	57.94				5.92*	7.23*	
Written Exercise Attitude Scale:	—																				
Att. toward Thought Questions	—																31.68				
Attitude toward Writt. Exer.	—																35.82				
Ecology Art Project Scale	—																				
Attitude toward Art Projects	—															61.86					

*Significance at the .05 level. The .05 levels for F values with the following degrees of freedom are: $F_{1,17} = 4.45$ $F_{2,17} = 3.59$ $F_{3,17} = 3.20$ $F_{6,17} = 2.70$ $F_{9,17} = 2.49$

[a] ω^2 = proportion of total variance explained (omega squared). The missing cell in the Latin square design was estimated to compute the total sum of squares.

[b] Means for Art Activity Treatment I differ from the actual means because a missing cell value was estimated in the analysis of variance.

was not replicated in a different experiment using fifth grade students. The third methodologically sound study found that questions framed by teachers are more effective than questions presented in text for second graders.

The results of previous research on teachers' higher cognitive questions are not conclusive. The main implications of the review of literature is that further research characterized by rigorous methodology is needed.

Treatments

The common basis for the four experimental treatments was the same ecology curriculum used in Study I. The curriculum included ten lessons, each requiring an hour of class time, and taught at the rate of one per day. Following viewing and/or reading of materials at the start of each lesson, students formed into their assigned treatment groups. The four treatments are as follows:

> 25% HCQ (Higher Cognitive Questions) Treatment. The same ecology teachers who participated in Study I conducted nine "scripted" discussions, one for each of nine lessons. Each discussion in each treatment consisted of sixteen questions. In the 25% HCQ treatment the discussions consisted of twelve fact questions and four higher cognitive questions. The questions pertained to the curriculum content which was included in the day's lesson. The ecology teachers probed and redirected students' answers to most of the questions in tis treatment, as in the 50% HCQ and 75% HCQ treatments (see below).
>
> 50% HCQ Treatment. In this treatment the discussions consisted of eight fact questions and eight higher cognitive questions. The eight fact questions were selected from the set of twelve fact questions in the 25% HCQ treatment. The four higher cognitive questions of the 25% HCQ treatment also appeared in the 50% HCQ treatment, plus an additional four higher cognitive questions.
>
> 75% HCQ Treatment. In this treatment the discussions consisted of four fact questions and twelve higher cognitive questions. The four fact questions and eight of the twelve higher cognitive questions were selected from the 50% HCQ treatment.
>
> Art Activity Treatment. The students in this treatment participated in nine sessions of ecology-related art activities. The ecology teachers were instructed not to ask any curriculum-related questions.
>
> The 50% HCQ Treatment was identical in format to Probing and Redirection Treatments in Study I. The Art Activity treatment was identical in both studies.

If the dependent variable was adjusted before the data were analyzed, the name of the adjusting variable appears in the column labled "Adjusting Variable." The majority of the adjusting variables are the pretreatment measures corresponding to the dependent variable, signified as "pre." Otherwise total reading score was generally the adjusting variable.

The column labeled "MS error" presents the error mean square from the analysis of variance of cell means or adjusted cell means and its degree of freedom for each dependent variable.

The next five columns list the F-statistics computed for the main effect of treatment, of class within squares, of teachers within squares, of squares and the treatment by square interaction, respectively. The adjacent columns show the strength of association statistics associated with each main effect. This statistic is interpreted as the percentage of variance in the dependent variable attributable to the treatment effect for that column.

The next four columns present cell means for each treatment condition in the Latin square design, that is, Probing and Redirection, No Probing and Redirection, Filler Activity, and Art Activity, respectively. For those variables which were adjusted before entry into the analysis of variance, these values are adjusted cell means.

The unadjusted cell means for the Written Exercise Treatment are also listed. The column labeled "95% Limits for Treatment 5" presents a "confidence" interval about each written exercise treatment mean. The mean square error term from the analysis of variance was used in calculating these limits.

The next three columns present F-statistics for the planned comparisons of treatment group means or adjusted means. The first of these columns compares Probing and Redirection with No Probing and Redirection (1 vs. 2); the second contrasts No Probing and Redirection with Filler Activity (2 vs. 3). The next column compares the average effect of the three discussion treatments with the non-discussion Art Activity treatment.

To assure that the results for various post and delay measures were not simply reflecting pre-existing differences among the sampled students, analyses of variance were performed on the total reading scores, i.e., the sum of vocabulary and comprehension subscale scores from the Comprehensive Tests of Basic Skills, and on average number of lessons attended by students within a group. No effects significant at the 5 percent level were observed, and omega squared values were generally small, ranging from .01 to .13 across the analysis of variance effects.

Differences Between Discussion Treatments. Only one of the planned contrasts involving comparisons of the discussion treatment means was statistically significant. Because of the large number of comparisons, there is a high probability that this difference is a chance finding.

Discussion Treatments versus Art Activity. Inspection of Table 1 shows that eight of the ten achievement measures yielded statistically significant differences favoring treatment groups exposed to discussion. With one exception each of the discussion treatments was also superior to the Art Activity mean on the two nonsignificant measures. It appears that discussion has a positive effect on learning by promoting acquisition and retention of facts, and by promoting skill in giving higher cognitive responses (both oral and written) to questions.

Only one of the attitude scales significantly differentiated the discussion treatments and the Art Activity Treatment. This difference, and each of the other nonsignificant differences, favored the discussion treatments slightly.

Written Exercises. Using the "test" of significance described above, it appears that the Written Exercise Treatment promotes more learning relative to the Art Activity Treatment means on a variety of variables related to acquisition and retention of information and skill in giving higher cognitive responses on oral and paper-and-pencil tests.

The means for the Probing and Redirection Treatment fell slightly above the 95 percent confidence limits for the Written Exercise means on several of the higher cognitive measures: the Content scales of the Oral and Transfer Tests and the Logical Extension scale of the Essay Test. A few other discussion treatment means fell above or below the 95 percent limits of the corresponding Written Exercise means, but they do not define a meaningful pattern. None of the discussion treatment means on the attitude scales fell outside of the 95 percent limits.

Other Effects. The analysis of variance confirmed prior expectations in revealing significant differences among classrooms on the majority of classroom type achievement measures. Also, as expected, the main effects attributable to ecology teachers were negligible. This result probably reflects the training given to the ecology teachers in following prescribed instructional patterns for each of the treatments.

Study II

Purpose

Study II was conducted to determine what student learning outcomes are affected by variations in teachers' use of higher cognitive questions in classroom discussions. The classification of a question as "higher cognitive" was based on two criteria derived from Bloom's taxonomy of educational objectives in the cognitive domain (Bloom, 1956). First, a higher cognitive question requires the student to state predictions, solutions, explanations, evidence, generalizations, interpretations, or opinions. The second criterion is that the prediction, solution, etc. asked for in the question is not directly available in the curriculum materials; instead, the student is required to expand on or use in a new way information presented in the curriculum.

The experiment was designed to test the belief of many educators that teacher use of higher cognitive questions is important for developing students' ability to think. On this basis it was predicted that discussions with a high percentage of higher cognitive questions would promote more learning than discussions with a low percentage of these questions. Another purpose of the experiment was to determine the effects of presence versus absence of discussions on student learning.

Review of Literature

The correlational studies relating cognitive levels of teachers' questions to student learning were reviewed by Rosenshine (1971), who concluded that "no clear relationship has been found between the frequency with which the teacher uses certain types of questions and the achievement of pupils..." (page 125). Further review and analysis by Heath and Nielsen (1975) indicates that the findings of these and similar studies are difficult to interpret because of flaws in research design. One problem is the limited range of student achievement measures which were used. For example, Wright and Nuthall (1970) found that the percentage of closed, that is, fact, questions was positively correlated ($r=.46$) with residual student achievement scores, whereas the percentage of open, that is, higher cognitive, questions was negatively correlated ($r=-.21$) with the same criterion. The measure of student achievement was a multiple-choice fact recall test, which probably is appropriate for measuring the effects of fact questions but not of higher cognitive questions. This problem is handled within the experiment reported here by including tests designed specifically to measure higher cognitive learning outcomes.

Winne (1975) reviewed twelve experimental studies of teacher questions and found that "nine of them probably could not speak validly to the degree of influence that teacher questions have on student achievement." One of the three studies which were methodologically sound found that higher cognitive questions lead to improved achievement relative to lower cognitive questions for second graders. However, this finding

As in Study I, audiotapes of the three discussion treatments were made for two different lessons. Analysis of the audiotapes indicated high fidelity of treatment, that is, close correspondence between the discussion scripts and the teachers' actual behavior. Live observations of the Art Activity lessons indicated that the ecology teachers adhered closely to the requirements of this treatment.

Student Sample

Study II was conducted in the Novato Unified School District, Novato, California. A total of twelve sixth-grade teachers, two in each of six schools, volunteered for their students to participate in the study. A total of 371 students from these classes served as the sample for the study.

Experimental Design

The four treatments--25% HCQ, 50% HCQ, 75% HCQ, and Art Activity--were manipulated in the same Latin square design used in Study I. Each discussion group consisted of six students. Since there were three discussion groups in each classroom, a total of eighteen students were involved in discussion treatments. The remaining students in the classroom were assigned to the Art Activity treatment.

Measures

With one exception, the same measures and order of administration used in Study I were repeated in the assessment of Study II outcomes. In Study II, the Information Test was scored on different scales than in Study I, as follows: Intentional Scale II contains eight items measuring students' ability to recall information covered in each of the discussion treatments. The 25% HCQ Incidental Scale II consists of seven items which were intentional only for students in the 25% HCQ Treatment; the items were incidental for students in the other treatments. Incidental Scale II consists of the items testing recall of information presented in the curriculum materials but not in any of the treatment variations.

Data Analysis Plan

The plan of data analysis used in Study I was repeated in this study, except that different planned comparisons were involved. In Study II, the following planned comparisons of treatment differences were examined: (a) 25% HCQ versus 50% HCQ; (b) 50% HCQ versus 75% HCQ; (c) 25% HCQ versus 75% HCQ; and (d) the discussion treatments as a whole versus Art Activity.

Findings

The results of the primary data analyses are summarized in Table 3 (measures of ability, achievement, and attendance) and Table 4 (attitude scales). These tables repeat the format used in Tables 1 and 2.

TABLE 3

Analysis of Variance Summary for Study II
Measures of Ability, Achievement, and Attendance

DEPENDENT VARIABLE	ADJUSTING VARIABLE	MSerror df=18	F VALUES AND ω^2 FOR ANALYSIS OF VARIANCE EFFECTS										TREATMENT MEANS				PLANNED COMPARISONS			
			Treatment		Class		Teacher		Square		Treatment by Square		25%HCQ Treatment	50%HCQ Treatment	75%HCQ Treatment	Art Activ. II	Treatments 1 vs 2	Treatments 2 vs 3	Treatments 1 vs 3	Treatments 1,2,3 vs 4
			$F_{3,18}$	ω^2	$F_{9,18}$	ω^2	$F_{9,18}$	ω^2	$F_{2,18}$	ω^2	$F_{6,18}$	ω^2	(1)	(2)	(3)	(4)	$F_{1,18}$	$F_{1,18}$	$F_{1,18}$	$F_{1,18}$
Number of Sessions Attended	—	0.51	0.18	0.00[a]	0.46	0.00	0.96	0.00	1.49	0.02	1.11	0.01	9.23	9.04	9.17	9.21	0.45	0.19	0.06	0.07
CTBS[b] - Total Reading	—	48.25	0.53	0.00	1.30	0.02	0.82	0.00	0.93	0.00	1.01	0.00	61.69	64.71	61.85	63.63	1.13	1.10	0.00	0.14
Ecology Information Test:																				
Intentional Scale II, post	—	0.33	8.55*	0.31	1.42	0.05	1.08	0.01	0.72	0.00	0.69	0.00	6.27	5.94	6.29	5.26	2.01	2.21	0.00	22.83*
Intentional Scale II, delay	total rdng.	0.40	12.51*	0.42	0.77	0.00	0.92	0.00	3.85*	0.07	0.54	0.00	6.19	5.26	5.85	4.74	13.12*	5.31*	1.73	24.10*
25% Intentional Scale II, post	total rdng.	0.35	9.46*	0.40	1.00	0.00	0.54	0.00	0.48	0.00	0.28	0.00	4.68	3.53	4.01	3.62	22.96*	3.97	7.83*	5.21*
25% Intentional Scale II, delay	total rdng.	0.49	5.20*	0.25	0.75	0.04	0.42	0.00	0.54	0.00	0.73	0.00	4.52	3.56	3.76	3.56	11.59*	0.60	7.30*	2.67
Incidental Scale II, post	total rdng.	0.48	7.49*	0.27	1.60	0.07	0.88	0.00	2.37	0.04	1.57	0.05	5.97	4.92	5.83	5.00	13.66*	10.29*	0.24	6.34*
Incidental Scale II, delay	total rdng.	0.68	7.30*	0.28	1.37	0.05	0.49	0.00	1.86	0.03	0.90	0.00	5.91	4.52	5.34	4.67	17.22*	5.97*	2.91	4.49*
Oral Test:																				
Content, post	pre	1.10	5.53*	0.19	0.42	0.00	0.73	0.00	9.88*	0.25	2.12	0.15	8.88	8.83	8.42	7.35	0.01	0.96	1.17	15.15*
Logical Extension, post	pre	0.68	4.91*	0.13	3.49*	0.25	1.19	0.02	3.22	0.05	1.42	0.03	4.03	3.80	3.10	2.95	0.50	4.30	7.73*	6.39*
Essay Test:																				
Content, post	pre	1.19	8.15*	0.14	9.77*	0.52	1.35	0.02	1.57	0.01	0.97	0.00	11.58	12.55	11.64	10.36	4.73*	4.11	0.02	18.54*
Logical Extension, post		0.71	1.18	0.01	2.49*	0.27	0.35	0.00	0.15	0.00	0.34	0.00	2.11	2.30	2.03	1.68	1.34	0.62	0.04	2.89
Transfer Test:																				
Content, delay	Ess. Cont,pre	2.29	0.32	0.00	1.75	0.15	0.34	0.00	1.78	0.04	0.58	0.00	8.79	8.99	8.62	8.40	0.10	0.07	0.61	0.61
Logical Extension, delay		0.39	0.64	0.00	3.33*	0.32	1.24	0.03	1.03	0.00	0.38	0.00	1.67	1.73	1.85	1.51	0.07	0.22	0.53	1.37
Written Question Generating Test:																				
Non-pertinent Questions		0.16	1.08	0.00	1.41	0.07	0.77	0.00	2.29	0.05	0.74	0.00	0.37	0.43	0.61	0.34	0.11	1.28	2.15	0.86
Pertinent Questions	pre	3.52	2.81	0.04	7.63*	0.43	1.33	0.02	15.10*	0.20	0.33	0.00	12.48	13.51	12.52	11.29	1.80	1.68	0.00	6.12*
Specific Questions		1.53	2.66	0.07	3.95*	0.36	0.40	0.00	0.50	0.00	1.02	0.00	3.24	4.16	3.12	2.81	3.36	4.25	0.05	2.87
Request for Rationale		0.18	0.37	0.00	0.61	0.13	0.65	0.00	0.27	0.00	0.21	0.00	0.56	0.51	0.42	0.39	0.08	0.29	0.65	0.42
Quality Rating		0.06	0.51	0.00	1.75	0.14	0.90	0.00	0.83	0.00	0.36	0.00	2.94	2.98	2.86	2.94	0.21	1.48	0.57	0.02
Oral Question Generating Test:	—																			
Non-pertinent Questions	—	0.03	1.23	0.00	1.61	0.05	0.98	0.00	3.86*	0.08	1.41	0.02	0.18	0.11	0.14	0.14	3.49	1.17	0.62	0.17
Pertinent Questions	—	0.45	0.61	0.00	0.66	0.00	0.98	0.00	0.49	0.00	1.22	0.03	1.85	1.87	1.56	1.64	0.00	1.25	1.11	0.27
Quality Rating	—	0.07	0.12	0.00	1.24	0.05	0.47	0.00	3.35	0.11	0.32	0.00	1.06	1.10	1.05	1.02	0.07	0.19	0.03	0.17

*Significance at the .05 level. The .05 levels for F values with the following degrees of freedom are:
$F_{1,18}$ = 4.41 $F_{2,18}$ = 3.55 $F_{3,18}$ = 3.16 $F_{6,18}$ = 2.66 $F_{9,18}$ = 2.45

[a] ω^2 = proportion of total variance explained (omega squared).

[b] CTBS = Comprehensive Test of Basic Skills

TABLE 4

Analysis of Variance Summary for Attitude Scales in Study II

DEPENDENT VARIABLE	ADJUSTING VARIABLE	MS_{error} df=18	F VALUES AND ω^2 FOR ANALYSIS OF VARIANCE EFFECTS										TREATMENT MEANS				PLANNED COMPARISONS			
			Treatment		Class		Teacher		Square		Treatment by Square		25%HCQ Treatment	50%HCQ Treatment	75%HCQ Treatment	Art Activ. II	Treatments 1 vs 2	Treatments 2 vs 3	Treatments 1 vs 3	Treatments 1,2,3 vs 4
			$F_{3,18}$	ω^2	$F_{9,18}$	ω^2	$F_{9,18}$	ω^2	$F_{2,18}$	ω^2	$F_{6,18}$	ω^2	(1)	(2)	(3)	(4)	$F_{1,18}$	$F_{1,18}$	$F_{1,18}$	$F_{1,18}$
Word Association Scale	—																			
Ecology	—	30.97	0.48	0.00	1.14	0.03	0.80	0.00	1.17	0.00	0.79	0.00	62.49	63.01	64.51	61.91	0.05	0.43	0.79	0.59
Balance of Nature	—	16.51	1.94	0.05	0.96	0.00	0.79	0.00	0.39	0.00	1.87	0.09	59.73	59.40	61.41	57.93	0.04	1.46	1.02	4.12
Wolf	pre —	10.13	6.33*	0.23	0.65	0.00	1.55	0.07	0.80	0.00	1.64	0.05	57.48	55.74	57.57	52.62	1.81	1.98	0.00	16.46*
Air Pollution	—	6.51	0.48	0.00	0.34	0.00	0.59	0.00	1.02	0.00	0.57	0.00	60.21	59.22	59.59	60.27	0.91	0.13	0.35	0.51
Alligator	pre —	10.62	7.40*	0.27	1.84	0.10	0.65	0.00	0.19	0.00	0.81	0.00	51.65	49.42	54.61	46.86	2.82	5.74*	0.51	16.15*
Water Pollution	—	6.76	0.53	0.00	0.72	0.00	0.75	0.00	4.21*	0.12	1.44	0.05	59.91	58.59	59.07	59.15	1.55	0.21	0.62	0.00
Gall-Crown Dis. Attitude Scale:	—																			
Att. toward Thought Questions	pre —	4.54	1.38	0.02	0.54	0.00	0.95	0.00	1.26	0.01	2.24	0.14	30.33	29.91	30.83	29.13	0.23	1.13	0.34	3.00
Attitude toward Discussion	pre —	22.44	0.65	0.00	1.23	0.04	0.45	0.00	1.29	0.01	1.73	0.09	56.14	55.69	54.17	53.92	0.05	0.62	1.04	0.80
Ecology Unit Opinions Scale:	—																			
Attitude toward Peers	—	1.69	2.55	0.08	1.04	0.00	0.64	0.00	0.37	0.00	1.63	0.07	16.87	17.12	17.06	15.83	0.21	0.01	0.12	7.44*
Attitude toward Teacher	—	10.88	0.21	0.00	0.61	0.00	1.46	0.08	1.24	0.01	1.07	0.00	58.09	58.09	57.70	57.16	0.00	0.08	0.08	0.53
Attitude toward Curriculum	—	5.77	0.29	0.00	0.53	0.00	1.35	0.06	3.49	0.10	0.43	0.00	32.30	32.03	31.49	31.61	0.07	0.30	0.67	0.17
Ecology Discussion Attitude Scale:	—																			
Att. toward Thought Questions	—	14.74	0.04	0.00	0.78	0.00	0.64	0.00	0.67	0.00	0.15	0.00	33.26	32.86	32.92		0.06	0.02	0.07	
Attitude toward Discussion	GDAS, — pre — disc	19.71	0.11	0.00	0.64	0.00	1.15	0.02	7.67*	0.28	0.48	0.00	59.67	59.39	60.23		0.02	0.13	0.00	
Ecology Art Project Scale:	—																			
Attitude toward Art Projects	—															63.36				

*Significance at the .05 level. The .05 levels for F values with the following degrees of freedom are:
$F_{1,18} = 4.41$ $F_{2,18} = 3.55$ $F_{3,18} = 3.16$ $F_{6,18} = 2.66$ $F_{9,18} = 2.45$

$^a\omega^2$ = proportion of total variance explained (omega squared).

To assure that the results for various post and delay measures were not simply reflecting pre-existing differences among the sampled students, analyses of variance were performed on the total reading scores, i.e., the sum of vocabulary and comprehension subscale scores from the Comprehensive Tests of Basic Skills, and on average number of lessons attended by students within a group. No effects significant at the 5 percent level were observed; the omega squared values were zero, with one exception. Similar results were obtained for number of sessions held.

Differences Between Discussion Treatments. The planned comparison of the discussion treatment means shows that percentage of higher cognitive questions was a statistically significant influence on the amount of information acquired by students as measured by subscales on the Ecology Information Test. The pattern of treatment mean scores is depicted in Figure 1. It appears that a U curve describes the relation between percentage of higher cognitive questions and achievement on intentional and incidental scales of the Ecology Information Test. In all cases, the 50% HCQ treatment has considerably lower outcomes on the subscales of the Ecology Information Test than the other two discussion treatments. The 75% HCQ and 25% HCQ treatment outcomes fall at similar points for the various subtests. Outcomes for the art activity treatment approximate those for the 50% HCQ treatment.

The 25% HCQ treatment was superior to the other two discussion treatments on the 25% HCQ Intentional Scale II. This finding is predictable, in that students in the 25% HCQ treatment had the advantage of answering (intentional) items which were not covered in the discussions of students in the 50% HCQ and 75% HCQ treatments.

Two of the comparisons involving higher cognitive achievement measures were statistically significant. Students in the 50% HCQ treatment outperformed students in the 75% HCQ treatment on one of the Oral Test measures. They also outperformed students in the 25% HCQ treatment (statistically significant) and in the 75% HCQ treatment (approaching statistical significance) on one of the Essay Test measures.

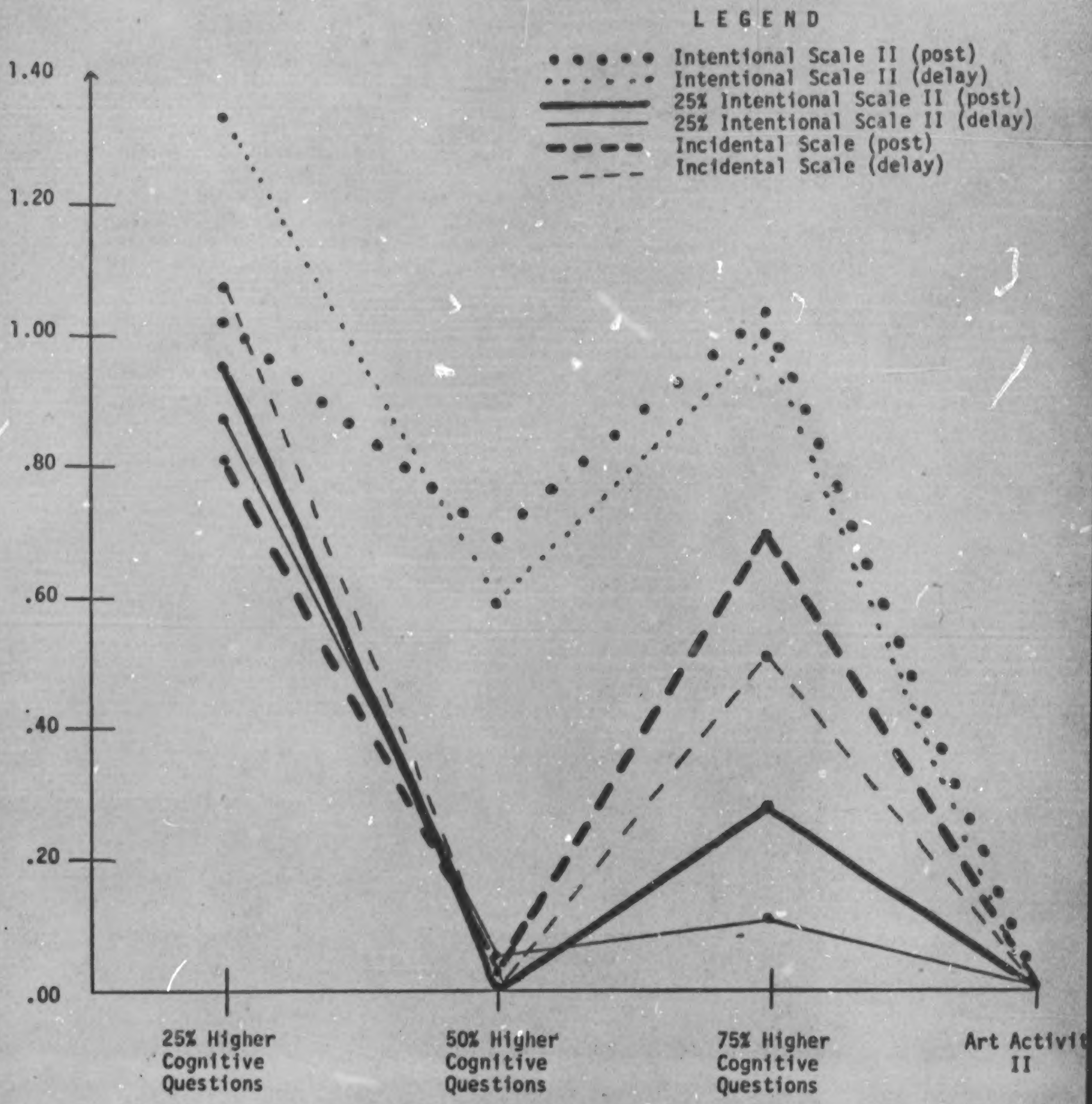
The mean scores of the discussion treatments on the attitude scales were quite similar. Only one of the planned comparisons was statistically significant.

Discussion Treatment versus Art Activity. With one exception the mean scores of students in the combined discussion treatments were statistically greater than the mean scores of students in the Art Activity treatment on the Information Test measures. Also, the mean scores of students in the combined discussion treatments were statistically greater than the mean scores of students in the Art Activity treatments on three of the six higher cognitive achievement measures. The mean score of students in each discussion treatment was greater than the corresponding Art Activity treatment mean score for the three measures which did not reveal a statistically significant difference.

FIGURE 2

Patterns of Treatment Differences for

Ecology Information Subtests in Study II



*Data points on the graph are based on unadjusted treatment means. The three recitation treatment means are expressed on the ordinate as absolute deviations from the art activity treatment means. The latter means serve as a baseline or zero value.

Planned comparisons involving the attitude measures revealed two significant differences. Students in the discussion treatments developed significantly more positive attitudes toward animals (wolves and alligators) presented in the curriculum than did students in the Art Activity treatment. Differences in scores on the other attitude scales, although not statistically significant, also generally favored the discussion treatments over the Art Activity treatment.

Other Effects. Very few of the other effects in the analysis of variance--class, teacher, square, and treatment by square--were statistically significant. Omega squared values were consistently small. As intended, the main effects attributable to ecology teachers were negligible. This result probably reflects the training given to the ecology teachers in following prescribed instructional patterns for each of the treatments.

Interpretation of Findings

The overriding finding of both studies was that discussion following critical viewing and/or reading of curriculum materials was substantially more effective than a no-discussion art activity in promoting student achievement. The achievement variables relate to acquisition and retention of intentional and incidental information, the ability to respond in oral and written form to curriculum-relevant higher cognitive questions, and ability to extend higher cognitive thinking into related content areas. There is some evidence, although not nearly as convincing as for the achievement variables, that discussion also is more effective in promoting positive attitudes toward the curriculum.

Additional insight into the effects of discussion can be gained by comparing the discussion treatments and the Written Exercise Treatment in Study I. Writing responses to questions appeared to develop knowledge acquisition as effectively as participation in a discussion of the same questions. However, written exercises seem less effective for improving higher cognitive response ability than oral discussions in which students' responses are probed and redirected. Presence-absence of probing and redirection in Study I did not have an effect on student learning. It appears that using probing and redirection to help students develop exemplary answers to questions is as effective as having the teachers directly provide an exemplary answer when students did not give them.

Variation in the percentage of higher cognitive questions in discussions does affect learning. However, the effects are puzzling. Relative to the 25% HCQ and 75% HCQ treatments, the 50% HCQ treatment was the least effective in promoting knowledge acquisition and retention, but it was the most effective in promoting higher cognitive performance. Since the discussions of the 50% HCQ treatment did not emphasize either fact or higher cognitive questions, it is possible that students were confused concerning the objective of the discussions--was the objective to rehearse facts, or to think about them? To lessen their sense of confusion, some students may have decided to concentrate on answering teacher higher cognitive questions and ignored the fact questions, thereby causing a decrement in performance on the Information Test.

As expected, students in the 25% HCQ treatment answered correctly more of the Information Test items which were intentional for them, but incidental for students in the other two treatments. This finding suggests the generalization that if the teacher wants students to learn certain information in the curriculum, it is effective to rehearse that information by asking questions in discussion.

In summary, the findings of the two studies demonstrate convincingly that an instructional pattern of reading curriculum material followed by small-group, semi-programmed (that is, "scripted") discussion is effective in promoting student learning. Variation in use of questioning techniques within this pattern appears to have less significance for promoting student learning. Further research is needed to determine whether the discussion method remains as effective when it is less structured and when it is conducted with larger groups of students. The methodology used in the two studies may be useful in investigating these, and related, research issues because it permits experimentation with high internal validity to be conducted in school settings.

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SECTION I

INTRODUCTION

CHAPTER ONE

PURPOSE

The Effective Teacher Education Program (ETEP) is a program of research and development in teaching that, to date, has had three major purposes:

- To develop teacher training materials that incorporate the microteaching approach to training and that develop teachers' use of specified teaching skills (the Minicourses);
- To study the effects upon student outcomes of specific teaching skills (for the most part these have been skills that were contained in one or more of the Minicourses);
- To test various approaches to the study of teaching.

The current programmatic effort is devoted entirely to the latter two objectives. Some two and a half years of research have been assigned to this effort. All research and development work to date has been sponsored by the U. S. Office of Education and the National Institute of Education.

The current program grew out of the Laboratory's earlier work in the field of teacher education. In 1966, the Laboratory's Teacher Education Program received federal funding to develop a series of skill-training packages for teachers called Minicourses (Borg, Kelley, Langer, and Gall, 1970). As a result of the development and testing of these courses, research evidence has been accumulated which shows that they are effective in bringing about desirable changes in teachers' classroom behavior. A small number of research studies (Hofmeister and Stowitschek, 1974; Strickler, 1972; and Ward, 1971) also have examined how the changes in teacher behavior brought about by Minicourse training subsequently affect student learning. Yet, we know relatively little about whether students of Minicourse-trained teachers learn more than students of untrained teachers.

In response to this issue, the Effective Teacher Education Program has undertaken an ambitious multi-year program of research on teacher effectiveness.

The research topics selected for study by ETEP were a direct outgrowth of the competency-based teacher education movement. Teaching skills considered important by theorists, researchers, and trainers (e.g., Dodl, 1972; Turner, et al., 1973) were included in the Minicourses that were developed during the initial seven years of work. These skills, in turn, became the focus of the current ETEP research. The three aspects of teaching that have been investigated include:

- Use of questioning skills. The two questioning studies reported herein represent the research in this area. The teaching skills of interest were taken from Minicourse 1, Effective Questioning - Elementary Level, and Minicourse 9, Higher Cognitive Questioning. As will be discussed in greater detail in this report, the purpose of Study I was to study the effects on student achievement and attitudes of teacher use of probing and redirection during a discussion. The purpose of Study II was to investigate the effects of teacher use during discussions of differing proportions of higher cognitive questions (25%, 50%, 75%) in relation to fact-recall questions on student achievement and attitude.

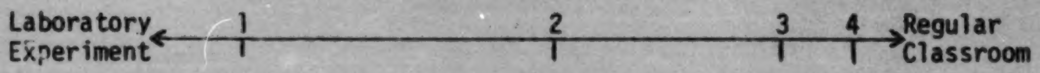
- Use of mathematics tutoring skills. Three studies were conducted, each employing a different individual in the tutorial role (regular classroom teacher, paraprofessional, junior high school student). The tutoring skills to be studied were taken from Minicourse 5, Individualizing Instruction in Mathematics.

- Use of an independent learning system. The purpose of this study was to investigate the effect upon students of an instructional system. Training in the implementation and use of the independent learning system was provided by Minicourse 15: Organizing Independent Learning--Intermediate Level.

In addition to studying the effects on students of teacher use of the above sets of skills, the ETEP research has explored four approaches to the study of teaching. The approaches fall along a continuum of research techniques that range from a tightly controlled laboratory experiment to work in the regular classroom where instructional and other variables are allowed to vary naturally (see Figure 1).

FIGURE 1

Continuum of Approaches to the Study of Teaching



1--Semi-programmed approach
2--Experimental Teaching Unit
3--Train teacher; study specific skills in specified instructional setting
4--Train teacher; establish instructional system; study overall effect.

The semi-programmed approach was used in the questioning studies. In this approach, the teacher is provided a set of curricular materials to use with the students. The sequence in which the materials are to be used is specified and the teacher is directed to conduct a discussion and/or some other activity as part of each day's lesson. When a discussion is specified, the teacher is provided a script which tells her/him the questions to ask and in what sequence. The script is only "semi" programmed because some teacher behaviors during a discussion are contingent upon student responses. For example, in the questioning studies, the script could dictate the questions to be asked and approximately how many times probing was to occur but it could not prescribe which student responses would be probed.

The Experimental Teaching Unit (ETU) approach was incorporated as a sub-study of the mathematics tutoring study with teachers as tutors. An ETU consists of a statement of teaching and learning objectives, curricular materials for students, and criterion-referenced pre and post tests. Teachers are allowed to organize and teach the unit as they wish. This approach, therefore, controls the content but not the process of instruction.

The third approach, training teachers to use a particular set of skills, then studying the effects of their application in a content area and/or instructional setting that is ongoing in the classroom, is a familiar form of research on teaching. It has been used in a large number of the existing studies of teachers. It was employed in the ETEP math tutoring studies.

The fourth approach parallels the research procedures applied to many previous studies of innovative educational programs. Teachers are trained in a new educational program; the program is put into operation; the effects on students are studied. This approach was used in the ETEP Independent Learning Study.

A report of findings follows for the two questioning studies conducted as part of the ETEP research. The purpose of this research was to investigate the effects of teacher use of discussion skills on student outcomes. More specifically, the research objectives examined in Study I were:

- To determine what student learning outcomes are affected by presence or absence of probing and redirection in discussions;
- To determine what student learning outcomes are affected by presence or absence of discussions;
- To determine the relative effect on student learning of teachers questions delivered in discussions compared with the same questions presented and answered in written format.

The objectives of Study II were:

- To determine what student learning outcomes are affected by variations in the percentage of higher cognitive questions in discussions;
- To determine what student learning outcomes are affected by presence or absence of discussions.

Both studies provided a test of the strengths and weaknesses of the semi-programmed approach to research on teaching.

CHAPTER TWO

BACKGROUND

The four volumes of this report describe two large-scale experiments that examined the effects of variations in teachers' questioning techniques on student achievement and attitudes. This volume presents the purpose, method, results and discussion of the experiments. Volume II includes the curriculum and treatment materials which were used. Volume III includes a copy of each student achievement and attitude measure, and its scoring key or scoring manual. In the final volume item statistics for the objective measures are presented.

STRATEGY FOR STUDYING THE EFFECTS OF TEACHING SKILLS

Planning for the Questioning Studies involved consideration and ultimate rejection of two major approaches for investigating teacher effects on student achievement. The first approach that was rejected was use of a Minicourse to train a group of teachers followed by confirmation that the desired behavior changes had occurred and observation to determine whether students of these teachers achieved at a higher level than students whose teachers did not receive Minicourse training (the approach used in the Tutoring Studies). In such an experimental design the independent variable would be the Minicourse and/or the skills used by the teacher as a result of Minicourse training. The second approach that was discarded was creation of experimental treatments in which teachers would be trained to exhibit different levels of specific teaching skills. These trained teachers then would teach under controlled conditions and their effect on student learning would be determined.

Both these approaches to research on teacher effects had advantages. The Minicourse validation approach has the character of "applied" research Its findings provide immediate evidence of the effectiveness of Minicourses which can be used by teacher educators in decision-making about their training programs. In contrast, the skill validation approach has the character of "basic" research. It lends itself better to laboratory-like control of the independent variables. The findings have less immediate implications for teacher training.

The research studies reported here build upon the second approach in that they utilize experimental treatments which incorporate specified levels of teaching skill use. However, two important modifications were added in these studies. Special teachers were hired and trained to conduct the specified discussions rather than training regular classroom teachers and semi-programmed discussion materials were provided to guide the discussions. The current research, therefore, approximates a laboratory-type experiment even more closely than special training of regular classroom teachers.

TEACHING SKILLS INCLUDED IN THE RESEARCH

As noted earlier, Questioning Studies I and II focus upon teaching skills included in Minicourse 1, Effective Questioning - Elementary Level (Borg, Kelley and Langer, 1970) and Minicourse 9, Higher Cognitive Questioning (Gall, Dunning, and Weathersby, 1971). The skills and course objectives are presented in Appendix A.

Three basic questioning skills are taught in the Minicourses. The first skill is using higher cognitive questions. These are questions which require the student to respond with an inference, evidence, generalization, explanation, solution, prediction, or opinion which cannot be obtained directly from the curriculum materials. Higher cognitive questions generally do not have a single correct answer; several answers usually are plausible and defensible. In contrast, a fact question requires the student to state a fact--a person, place, date, object, term, definition, etc., generally explicitly stated in the curriculum material. Fact questions usually have a single correct answer. A variant of the fact question is the multiple-fact question in which two or more facts comprise a correct answer to the question (e.g., "What does a wolf look like?").

The second questioning skill, redirection, occurs when the teacher calls on more than one student to respond to a question already asked of another student. The third technique, probing, occurs when the teacher seeks to improve the quality of a student's initial answer to a question by asking a follow-up, that is, a "probing" question.

Review of Literature (Higher Cognitive and Fact Questions)

A group of 13 correlational studies reviewed by Rosenshine (1971) comprise the bulk of research on levels of questioning, in most of these studies operationalization of question levels was insufficiently described to permit replication in the current research. For example, in the study by Connors and Eisenberg (1966), the teacher variable reviewed by Rosenshine was activities focusing on intellectual growth, such as "language, concept, or symbolic training; factual knowledge about the world; development of sensory abilities, etc." In the study by Furst (1967), lines of transcripts of teacher-student classroom interaction were categorized as analytic, evaluative, or empirical (fact stating or explaining). These variables included both teacher talk and student talk so that the relationship between cognitive level of teacher talk or cognitive level of teacher questions to student achievement cannot be isolated.

Several studies reported factor loadings of a teacher questioning variable from a factor analysis of many teacher variables (Perkins, 1965; Soar, 1966; Spaulding, 1965; Solomon, Bezdek, and Rosenberg, 1963). It appears that the factors, rather than the questioning variable, were correlated with student achievement. These correlations are difficult to interpret because, as Heath and Nielsen (1973) point out, "A significant correlation between a factor and student achievement...does not necessarily imply significant correlations between achievement and every teacher-behavior item loading on that factor, (p. 13)."

Wright and Nuthall (1970) found that the percentage of closed, i.e., fact recall, questions was positively correlated (r=.46) with residual student achievement scores, whereas the percentage of open, i.e., higher cognitive, questions was negatively correlated (r=.21) with the same criterion. The measure of student achievement was a multiple-choice fact recall test, which probably is appropriate for measuring the effects of fact questions but not of higher cognitive questions. As Wright and Nuthall note, "While [open questions] did not show a positive relationship with achievement, they may well have been positively related to other long-term cognitive objectives, (p. 498)." The results of this study suggest however, that fact questions in discussions are useful for improving students' ability to recall these facts in subsequent testing.

We have identified four experimental studies in which the cognitive level of teachers' questions has been related to student achievement (Buggey, 1971; Savage, 1971; Tyler, 1971; and Ryan, 1973).

The studies by Buggey, Tyler, and Savage were doctoral dissertations at the University of Washington and applied similar methodologies. Buggey studied the relationship between teachers' use of fact versus higher cognitive questions and the social studies achievement of second-grade children. One hundred eight second-grade children were randomly assigned to three treatment groups for six weeks of instruction. One treatment consisted of scripted lessons in which there were 70 percent fact questions and 30 percent higher cognitive questions. A second treatment consisted of lessons with the reverse proportions of higher-order and fact questions. A third treatment received no special instruction. Posttests consisted of two multiple-choice tests, each of which contained five questions from each of the six levels in Bloom's taxonomy of cognitive objectives. The post-test mean scores for treatment groups were all significantly different from each other. The treatment using 70% higher cognitive questions promoted a significantly greater amount of learning than the treatment using only 30% higher cognitive questions, while both treatments were statistically different from the control group.

Savage attempted to replicate these findings at the fifth-grade level, but was unsuccessful. One group received instruction consisting predominantly of fact questions, another group received predominantly higher cognitive questions, and a control group received no special instruction. A significant difference was found between the control group and the two treatment groups but the two treatment groups did not differ significantly.

Tyler's study was similar to Buggey's except that one treatment consisted of a scripted lesson in which the teacher orally asked 70 percent higher cognitive questions and 30 percent fact questions, while students read the questions for themselves in the second treatment. Students in a third group received no special instruction. The posttest means were all significantly different from each other, with the oral higher cognitive treatment group scoring higher than the written group, which was greater than the control group.

Two problems in the studies by Tyler, Buggey, and Savage were that teachers were not monitored to determine their fidelity to the scripted lessons, and the possibility of differential performance on fact and higher cognitive posttests was not considered.

In the study by Ryan (1973), fifth and sixth grade students were randomly assigned to three groups for nine daily lessons. The treatments were 75 percent higher cognitive questions, 5 percent higher cognitive questions, or no special instruction. A different teacher taught each group. Multiple choice posttests of fact-recall and higher cognitive achievement were administered following the treatment and again two weeks later. On all measures (immediate fact-recall; immediate higher cognitive; retention fact-recall; retention higher cognitive), the higher cognitive group did slightly, but not statistically significantly better than the fact group; both groups performed at a much higher level than the control group. However, these latter differences probably resulted from the fact that the control group studied different curriculum material than the experimental groups. Also, since a different teacher taught each group, the findings could have been due to a teacher effect rather than a treatment effect.

An additional inadequacy of Ryan's study and the studies by Buggey, Tyler, and Savage was that the posttests did not measure students' oral responses to higher cognitive questions.

Rosenshine (1970) has reviewed six other experimental studies which deal with the relationship between level of teacher questions and student achievement. However, according to Rosenshine there are research design difficulties in all the studies which limit their usefulness for drawing meaningful and valid conclusions about the effectiveness of teacher use of fact versus higher cognitive questions for promoting students' learning.

The current research attempts to reduce the weaknesses identified in the previous research on higher cognitive questioning particularly those related to:

- fidelity of treatment;
- conceptualization and measurement of student outcomes;
- opportunity for students to learn the content of the posttest;
- random assignment of students;
- requirements of the statistical procedures used.

Literature Review (Probing and Redirection)

Rosenshine (1971, pp. 134-136) was able to identify only three studies, all correlational, in which teachers' use of probing or redirection following a student's initial answer to a question was related to student achievement measures. Two of these studies are not reviewed here because the investigators did not correlate teacher behaviors with student achievement; instead, the factors on which the teacher behaviors loaded were correlated with student achievement. As mentioned previously, this procedure probably leads to erroneous inferences about the effects of the teachers' behavior on student learning.

In the third study (Wright and Nuthall, 1970), teacher redirection had a high positive correlation (r=.54) with student achievement scores. However, asking a follow-up question at the same or higher cognitive level as the initial question was only slightly correlated with student achievement (r=.20). As noted previously, a major problem with this study was that the posttest consisted of fact-recall items only. Also, the investigators did not distinguish between probing and redirection in response to fact versus higher cognitive questions during the treatment lessons.

Because of problems with use of factors rather than specific teacher behaviors and limitations in posttest measures, it is reasonable to conclude that previous research generally does not yield interpretable findings concerning the effectiveness of teacher probing and redirection. Therefore, the present studies give special consideration to these problems as well as to the problems of random assignment of students and opportunity to learn.

OVERVIEW OF QUESTIONING STUDIES

Two studies of teacher use of questioning skills are presented in Chapters Three and Four (Study I), and Five and Six (Study II) of this report.

Study I, The Effects of Teacher Use of Probing and Redirection on Student Achievement and Attitudes, was designed to determine which student learning outcomes were affected by presence or absence of probing and redirection in discussions and presence or absence of discussions themselves.

It also investigated the relative effect on student learning of teachers' questions delivered in discussions compared with the same questions presented and answered in written format.

Study II, The Effects of Teacher Use of Higher Cognitive Questions on Student Achievement and Attitudes, was designed to determine which student learning outcomes were affected by variations in percentage of higher cognitive questions in discussions and presence or absence of discussions.

As noted above, both studies were designed to reduce or eliminate several previously identified research problems. These included the need for random assignment of students to treatment, matching outcome measures with the intended instructional purpose(s) of the treatment conditions, controlling for opportunity to learn, control and monitoring of treatment conditions to be sure they were maintained, and investigation of the critical assumptions underlying the statistical procedures used in analyses of data.

SECTION II

STUDY I

The Effects of Teacher Use of Probing and Redirection on Student Achievement and Attitudes

Study I, The Effects of Teacher Use of Probing and Redirection on Student Achievement and Attitudes, is discussed in two chapters. First, the methodology of the experiment is described. Second, the results of the experiment are presented. A discussion of the results of both Study I and Study II is presented in Section IV of this volume. Technical issues are discussed in the appendices.

CHAPTER THREE

METHODOLOGY OF STUDY I

The discussion of methodology covers six main topics: treatments, curriculum, participants including both teachers and students, instrumentation, research design, and statistical analysis procedures.

Since both Study I and Study II, A Study of the Effects of Teacher Use of Higher Cognitive Questions on Student Achievement and Attitudes, were planned to explore similar problems related to classroom discussion, methodological strategies were devised with both studies in mind. Consequently, the discussion of methodology for Study I will occasionally refer to Study II. However, once the main procedures were adopted, both studies proceeded as independent experiments.

TREATMENTS

The discussion of treatments includes two sub-topics. The first is a description of the treatments and the procedures related to their implementation. The second is a discussion of the fidelity of treatment. Fidelity of treatment provides information on the disparity between the intended treatment and the actual treatment as implemented by the participants. The more closely the actual treatment corresponds to the intended treatment, the greater the treatment fidelity is said to be. Fidelity of treatment is an important aspect of this kind of experiment because results can easily be contaminated by uneven or idiosyncratic implementation of the intended treatment.

Description of Treatments

Study I included five treatment conditions--three discussion treatments, an art activity treatment, and a written exercise treatment. All treatments were administered to students randomly formed into treatment groups from sixth-grade classrooms in a local school district. All treatment groups used a specially prepared curriculum on ecology. The treatments were administered by specially-trained teachers (referred to in this report as "ecology teachers"), not by the students' regular teachers. Each ecology teacher taught four different treatment groups each day. The curriculum, student sample, and teachers are described in the next section of this chapter. A discussion follows of each of the treatment conditions.

Discussion Treatments. As noted above, the three discussion treatments in Study I all used the ecology curriculum. This curriculum consisted of one warm-up lesson and nine regular lessons, one lesson a day was conducted during a fifty-minute session, over a two-and-one-half week period. Within each fifty-minute session, presentation of curriculum materials typically consumed 15 to 20 minutes. The next 20 to 30 minutes were used for the various types of discussions. Each discussion, regardless of treatment condition, consisted of 16 questions. The decision to use 16 questions was based upon pilot work, which indicated that teachers in the sixth grade typically could ask 15 to 20 substantive questions in a 20-to 30-minute period without a time difficulty for either the teacher or the students.

In Study I the same 16 questions were asked in all discussion treatment conditions. These 16 questions contained four fact, four multi-fact, and eight higher cognitive questions. The fact and multi-fact questions corresponded to Bloom's knowledge levels. The higher cognitive questions were based on the processes described for the upper levels of Bloom's cognitive taxonomy.

Two criteria were used to generate the fact and multi-fact questions. First, each question required the statement of a fact (or facts). Second, the fact required was explicitly stated in the curriculum material for the same day's lesson in which the question was asked. No questions were repeated in different lessons.

The higher cognitive questions also were constructed according to two criteria. First, each higher cognitive question required predictions, solutions, explanations, evidence, generalizations, interpretations, or opinions. Second, these predictions, solutions, etc. were not directly stated in the curriculum material but required the student to expand on or use the information presented in the day's lesson in a new way. The classification system* used for the higher cognitive questions was as follows:

- Analysis questions, those which elicit:
  - motives or causes of observed events;
  - inferences, interpretations, or generalizations;
  - evidence to support inferences, interpretations, generalizations.
- Synthesis Questions, those which elicit:
  - predictions;
  - solutions to problems;
  - original communications.
- Evaluation Questions, those which elicit:
  - opinions about issues;
  - judgments about the validity of ideas;
  - judgements about the merit of problem solutions.

The discussions were developed so that the relative proportions of each type of higher cognitive question in a lesson were balanced. Thus,

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* This classification system is the same as that which appears in Minicourse 9. See Appendix A for description of Minicourse 9 content.

"analysis," "synthesis," and "evaluation" questions were approximately equally represented. To insure that questions were relevant to the curriculum, the curriculum objectives (see Table 4) were used as a basis for constructing the questions.

Building around these criteria 16 questions were generated. The three discussion treatments that were developed from these questions included:

- Probing and redirection treatment. This treatment called for each of the four multi-fact and the eight higher cognitive questions to be probed and redirected twice. On the basis of pilot work,* these discussions were expected to take approximately 23 minutes.

  No probing and redirection treatment. The teachers asked the same 16 discussion questions as in the above treatment. No questions were probed or redirected. These discussions were expected to require approximately 13 minutes based upon pilot work.

- Filler activity treatment. This treatment included the same 16 questions as the above two treatments. It provided a controlled comparison for the difference in time on task between the probing and redirection and no probing and redirection treatments. The treatment was identical to the no probing and redirection treatment but added a filler activity approximately 10 minutes in length to each discussion. The filler activities included the following:

  Lesson 1. The students each made a list of things that could be done to improve their own environment either at home or at school.

  Lesson 2. Students completed a crossword puzzle based on the theme of DDT taken from the lesson which had just been read.

  Lesson 3. The students wrote environmental cinquains. This was a poetry lesson in which they described elements in their immediate vicinity which either pleased or displeased them.

  Lesson 4. Each student designed a patch, first on paper, and later on material, to be sewn on an old garment. The ecology symbol and various animals were the most common designs.

  Lesson 5. This was a crossword puzzle about alligators.

  Lesson 6. The students cut out patches and sewed them on old clothing.

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* The discussion treatments were pilot tested as part of the initial try-out of the ecology curriculum. See pages 35 to 37 for a description of the pilot test.

Lesson 7. The students made collages using primarily photographs from old magazines. A popular theme was the polluted environment.

Lesson 8. The students listened to Marvin Gaye's "Mercy, Mercy, Me...the Ecology," a popular song, and then read and discussed the relevant lyrics.

Lesson 9. The culminating activity was for each student to write a letter to a politician urging action to preserve our natural resources.

The decision to use these particular filler activities was arbitrary in that time on task can be operationalized in different ways. They represent one method of keeping students "on task," that is, engaged in an activity which is intended to foster learning and which is directed to the curriculum content. It is possible that other filler activities that could be designed to control for time on task might produce learning outcomes different than those observed in this study.

An important feature of the discussion treatments was the use of a "semi-programmed" discussion technique. In the semi-programmed discussion. the teacher follows a script which tells him the questions to ask and in what sequence. The script is only "semi" programmed because some teacher behaviors are contingent upon student responses. For example, in the probing and redirection treatment, the teacher could not probe a student's response to elicit a rationale if the student was unable to express any response to the initial question (e.g., an "I don't know" response). Thus, the script could dictate the question to be asked and approximately how many times probing was to occur but it could not prescribe which student response would be probed.

To insure that students in all discussion treatments were exposed to the same amount of correct information, a set of exemplary responses was provided for each question. In cases where no student gave an acceptable answer to a question, the teacher provided one from this set.

The reason for using the semi-programmed discussion format was to control, as much as possible, the content and form of the treatment received by the students. As noted in the review of the literature, one flaw in past research has been possible variability and imprecision in definition of the discussion strategy used by teachers. The semi-programmed discussion in large part overcomes this problem. It also simplifies the task of constructing posttests which accurately reflect students' opportunity to learn a given body of curriculum material. The use of semi-programmed discussions in this type of research is not novel; precedents can be found in the research of Buggey (1971), Tyler (1971), Savage (1971), Ryan (1973), and Hunt, Joyce, Greenwood, Noy, Reid, and Neil (1974).

Art Activity Treatment. The students in this treatment participated in nine sessions of ecology-related activities. During these sessions, the ecology teachers were instructed not to ask questions of any type. The time for each art activity lesson was approximately equal to that of the probing and redirection treatment (23 minutes).

The sequencing and types of art activities were allowed to vary at the discretion of the ecology teachers. Each teacher was given a packet of art activity suggestions. A particular activity could last for one period or could be continued over successive days. A brief description of some of the activities follows:

> Ecology postcards. The students designed postcards to send to penpals or friends. There was an ecology caption on one side, a drawing on the other.
>
> Imaginary animals. The students were instructed to draw animals of the year 2,000, animals which had to adapt to pollution in order to survive.

Baker's clay animals. Baker's clay is a pliable substance from which the children were able to model endangered animal species. The figures were then baked and painted.

Box environments. For this project, the students brought materials from home or used objects found on the school grounds. A cardboard box served as an environment for animal cutouts, twig fences, etc.

Vegetable prints. Such vegetables as carrots, bell peppers, and onions were chopped in half and covered with ink on one surface. They were then used to imprint patterns on construction paper.

Sandpaper prints. The students made drawings on sandpaper and then filled them in with crayon. The sandpaper design was placed face-down on cloth (usually a T-shirt) and ironed on, creating an interesting effect.

Junk sculptures or mobiles. The students were encouraged to make sculptures or mobiles out of ordinary objects which would otherwise be thrown away.

Several of the art activities are described in more detail in Volume II.

Written Exercise Treatment. The written exercise treatment utilized the same ecology curriculum as the discussion treatments. However, the students were presented the 16 questions that served as the basis for the discussion treatments in booklet forms and were asked to write their answers to each question. (A sample booklet is presented in Volume II of the report.) Students were allowed 23 minutes for this task in each of the nine lessons.

One problem with this treatment was that students often wanted to discuss the curriculum materials, but the treatment specifications prescribed that the teacher could not conduct a discussion. Therefore, it took a fair amount of perseverance on the student's part to do nothing but write answers each day. In fact, the teachers working with this treatment reported that they had difficulty maintaining student interest in the assigned task. In order to provide some reinforcement and motivation for their work, the students received written comments from the ecology teachers regarding their answers. Wildlife stamps were given for outstanding work. At the end of each period, they also were given an opportunity to compare their answers with exemplary responses. This procedure controlled for information input in the same way as the exemplary responses provided by the teachers did in the discussion treatments.

Summary of treatments. Table 1 summarizes the five treatment conditions used in Study I. This table illustrates the similarities and differences among the treatments.

Fidelity of Treatment

Fidelity of treatment was investigated along two dimensions. First, a check was made on how closely the ecology teachers adhered to the scripted questions in each discussion treatment. Second, the time required to conduct lessons in each treatment was checked. A discussion of the results of both these checks is presented below.

Adherence to treatment conditions. Inasmuch as the discussion treatments were semi-programmed, adherence to the conditions of question sequence, probing and redirection, and filler activity was essential for maintenance of treatment. Likewise, in the written exercise and art activity treatments, it was essential that the teachers conducted no discussions.

The extent to which the ecology teachers maintained the various discussion treatment conditions was checked by audiotaping three of the discussions conducted by each teacher on each of the two days (Lesson 2 and Lesson 9.) This sample of six discussions per teacher was rated to establish treatment fidelity. A total of 72 discussions were rated for Study I. These were contained on a set of 52 audiotapes which included

TABLE 1

Study I

Treatments

Treatment	Content
Probing and Redirection	Curriculum materials followed by discussion including 4F+4MF+8HCQ and probing and redirection.
No Probing and Redirection	Curriculum materials followed by discussion including 4F+4MF+8HCQ without probing and redirection, and without filler activity.
Filler Activity	Curriculum materials followed by discussion including 4F+4MF+8HCQ and filler activity.
Art Activity	Curriculum materials followed by ecology-related art activity.
Written Exercise	Curriculum materials followed by written response to 4F+4MF+8HCQ.

F = Fact question
MF = Multi-fact question
HCQ = Higher cognitive question

discussions from both Studies I and II. Thirty of the tapes were scored by two raters. Twenty-two tapes were scored by only one rater (due to cost considerations). Since the tapes were assigned for scoring on a random basis, there is no reason to believe that the single-scored tapes differed systematically from the double-scored tapes.

The audiotapes were first scored to determine whether the ecology teacher:

- asked or omitted each scripted question;
- made substantial changes in the wording of a question;
- asked the questions in a different order than they were listed in the script.

Based upon this analysis, the teachers appear to have followed the question format. In only six of the 144 discussions scored for Studies I and II combined did teachers change the order of the questions. Other deviations either did not occur or occurred very infrequently.

The audiotapes also were rated for frequency of several teacher behaviors that were considered to affect the treatment conditions. These included probing, redirection, praise, giving feedback concerning the accuracy of a student's answer, and giving all or part of an answer to the question (rather than the student giving the answer). Interrater agreement on the frequency of occurrence of these behaviors was checked for those audiotapes scored by both raters. The intraclass correlation coefficients for the raters were .93 for probing, .90 for redirection, .91 for praise, .65 for feedback, and .91 for giving answers. Table 2 presents the results of teacher use of the behaviors. Most importantly, the use of probing and redirection was minimal in the no probing and redirection and filler activity treatments. Also, in these treatments the ecology teachers provided the answer for the students more frequently than was done in the probing and redirection treatment. This was as intended since the teacher giving the answer served as the mean for providing necessary information when Probing and Redirection could not be used to bring out the answer from the students.

Teachers were given only general instructions concerning use of praise and feedback. It appears that these reinforcement techniques were used more frequently in the probing and redirection treatment than

TABLE 2

Study I

Teacher Behavior Patterns in Discussion Treatments

Teacher Behavior	Discussion Treatments					
	Probing and Redirection N=12 teachers		No Probing and Redirection N=12 teachers		Filler Activity N=12 teachers	
	$\overline{X}$ frequency	S.D.	$\overline{X}$ frequency	S.D.	$\overline{X}$ frequency	S.D.
Lesson 2						
Probing	21.45	6.88	3.29	2.60	2.58	3.25
Redirection	22.96	11.34	0.33	0.49	0.58	1.00
Praise	8.83	7.46	5.87	4.11	4.50	2.88
Feedback	9.50	4.81	5.38	1.90	4.58	2.10
Gives Answer	3.25	2.46	9.67	1.80	9.83	2.19
Lesson 9						
Probing	29.92	11.90	1.00	0.93	1.38	1.80
Redirection	24.38	10.21	0.54	1.16	1.08	1.04
Praise	8.83	6.95	5.92	4.63	5.50	4.22
Feedback	8.46	6.80	8.58	3.90	6.79	3.41
Gives Answer	3.75	2.99	9.12	1.75	9.29	1.79

in the other two treatments, probably because the former treatment required more student participation and hence more opportunity for reinforcement.

Adherence to treatment conditions for the written exercise and art activity treatments was monitored by staff observations of randomly selected lessons. (The audiotape procedures were not used for these treatments because few verbal events occurred that could be scored in a manner that was meaningful to the study.) Generally, the prescribed conditions were maintained.

Average length of treatment sessions. In Study I, the ecology teachers were asked to maintain a diary in which they recorded the length of each treatment session which they taught. These times were compiled and summarized in order to determine how closely the average treatment times approximated the 23 minute pre-study estimate set for the probing and redirection and filler activity treatments, and the 13 minute estimate for the no probing and redirection treatment. No analysis was necessary for the art activity and written exercise treatments since each was stopped at the end of 23 minutes.

Table 3 contains the teachers' estimated times for each treatment. In the filler activity treatment, the average times are for the discussion portion of the treatment only. The additional ten minutes of filler activity must be added to this time estimate to obtain the total treatment time.

Based upon mean time for the treatments over all teachers and lessons, the expectations were met: the probing and redirection treatment averaged 23.37 minutes overall, the filler activity treatment averaged 23.71 minutes including the 10 minutes of filler plus an average of 13.71 minutes of discussion, and the no probing and redirection treatment averaged 13.84 minutes.

TABLE 3

Study I
Average Length of Discussion Treatment Sessions

Teacher	Probing & Redirection		No Probing & Redirection		Filler Activity	
	$\bar{x}$ minutes of discussion	S.D.	$\bar{x}$ minutes of discussion	S.D.	$\bar{x}$ minutes of discussion	S.D.
1	24.33	3.00	14.11	1.45	13.89	.78
2	19.56	4.98	12.45	1.74	12.22	3.38
3	24.89	1.06	12.78	.97	13.00*	2.51
4	24.50*	1.85	13.89	1.06	15.89	2.80
5	21.89	3.10	13.22	4.06	12.44	1.94
6	24.22	1.39	12.67	1.23	12.67	.71
7	25.11	2.98	16.25*	1.67	14.78	2.11
8	19.38*	2.20	15.00*	5.35	15.00*	4.87
9	22.75*	3.62	13.56	1.13	13.78	1.30
10	25.22	4.92	12.78	.67	12.67	1.87
11	21.11	4.62	11.44	1.94	10.78	1.79
12	27.43**	2.88	17.88*	2.64	17.38*	2.13
TREATMENT	23.37	2.46	13.84	1.80	13.71	1.81

Note: Mean based on nine lessons, except when indicated by asterisk
* = 8 lessons; ** = 7 lessons; *** = 6 lessons

Individual ecology teachers varied from the desired times. In particular, Teachers 7 and 12 tended to exceed the expected lesson times in all the discussion treatments. Teachers 2 and 11 were low in amount of time given to all the discussions. However, the times for these teachers were within a reasonable approximation of the expected times for each treatment condition. The average times for the other eight teachers were very close to the expected length for each treatment.

CURRICULUM

Description

The means by which the five treatments in Study I were implemented consisted of a specially-prepared ten-lesson ecology curriculum. An assumption underlying the study was that the effects of the treatments would not appear after a single discussion since students would need to become familiar with the questioning style of the teacher and would need to receive practice to permit effects to accrue. Therefore, it was decided to extend each treatment over ten 50-minute sessions, one each day, since this duration subjectively appeared to be sufficient for effects to emerge.

Although a longer treatment period might have been desirable, the logistical constraints in this study did not permit such an extension. In particular, school districts might have been reluctant to permit their students to participate in the experimental curriculum for a longer period of time in place of their regular studies.

The decision to make each lesson 50 minutes in length allowed ample time for organizing the classroom into treatment groups, distributing curriculum materials, etc. Since the actual discussions and other treatment activities lasted approximately 25 minutes, the 50-minute period allowed approximately 15 minutes for presentation of curriculum material in each session and approximately 10 minutes for organizational activities.

To insure that an identical information base existed across all treatments, all students in each treatment were provided with the same curriculum materials. The following criteria were used in selecting these materials:

1. They could be organized into ten lessons, one per day. The amount of viewing and/or reading required would be no longer than 10-15 minutes, so that sufficient time remained for completing the discussions and other treatment conditions and for management activities.
2. They would contain a mixture of simple facts and more complex ideas which could be used as a basis for generating fact and higher cognitive questions.
3. They would present information which students had not already learned.
4. They would cover topics perceived relevant by the participating school districts and consistent with their objectives.
5. The reading difficulty would be at or below the students' grade level so that reading ability would not be a major influence on students' ability to participate in the discussion treatments.
6. They would be sufficiently varied and appealing to hold the attention of a typical sixth-grade student for a period of two weeks.

Existing curriculum materials which met these requirements in all respects could not be located. Therefore, a new curriculum was developed, using existing materials when possible. Ecology was selected as the topic for the unit because it was thought that it would be perceived as highly relevant by the participating school districts and would appeal to sixth-grade students. Both these assumptions were later confirmed in practice.

Objectives for the curriculum unit were based upon Bloom's taxonomy of cognitive objectives (Bloom et al., 1956). This taxonomy incorporates higher cognitive objectives (which were the primary concern of Study II) and accommodated the construction of lesson plans for the discussion and written treatments.

The curriculum objectives are presented in Table 4. The objectives served as the basis for constructing and organizing the content of each lesson and for constructing the questions to which the students responded in oral or written form.

The curriculum included a variety of materials: printed handouts, a game, a film, and two film strips. A copy of each of the printed handouts is included in Volume II of this report. A description follows of the content and materials for each of the ten lessons.

Warm-up Lesson. This lesson served as an introduction to succeeding lessons. It gave the ecology teachers and the students an opportunity to get acquainted and provided students with an overview of the ten-day curriculum. Part of the 50-minute period was spent playing an ecology board game, Cycles, developed by the Society for Visual Education Corporation.

Lesson 1. The film What Ecologists Do, from Centron Educational Films provided the content for this lesson. Its primary function was to introduce the concept of ecology. The film shows numerous instances of ecologists studying the interrelationships between organisms and their environments. The plight of the bald eagle is highlighted. After viewing the film, the students read a brief handout summarizing the content of the film.

TABLE 4

Objectives of the Experimental Curriculum Unit

As a result of exposure to the curriculum unit, the student should be able to:

Knowledge

1. state facts about the natural environment; balances that exist in nature; man's contribution to imbalances and to environmental pollution; and solutions to correct imbalances and pollution.

Analysis

2. give reasons to explain why changes occur in the natural environment.

3. give evidence to support these generalizations:

   - all things in nature depend on each other
   - man's actions can affect the natural environment
   - changes in the natural environment can set off a chain reaction that upsets the balance of nature
   - we need to take care of our natural environment.

4. infer the above generalizations when presented with appropriate data.

Synthesis

5. develop defensible solutions to the problem of preserving and improving the environment.

6. make predictions about consequences of changes in the natural environment.

Evaluation

7. state reasoned opinions concerning the proper relationship between man and the environment.

Lesson 2. This was the first lesson in which the curriculum materials were in a written format. The content of the lesson was derived from a variety of sources. It focused on DDT and insect poisons. Building on concepts introduced in the previous lesson, Lesson 2 emphasized the unanticipated consequences of introducing dangerous new elements into the environment.

Lesson 3. A filmstrip, Nature's Balance, produced by Visual Education Consultants Corporation, provided the content for this lesson. Several additions and clarifications were made in the filmstrip's text to make it suitable for sixth grade students. The focus was on the interconnectedness of all living things; that is, the balance of nature and how easily it can be upset by the introduction of a foreign animal species.

Lesson 4. As with all of the other written lessons, this lesson on wolves was supplemented with photographs and illustrations. It was adapted from a chapter in Wildlife in Danger by Ivan Green. The lesson was a case study of the wolf as an animal facing the imminent threat of extinction. The question of what could be done to remedy this situation was left open-ended for students.

Lesson 5. This lesson was adapted from the article "What Good's a Gator?" in Xerox's Nature and Needs series, and updated with recent information on the rapidly increasing population of alligators. The importance of the alligator for the survival of all swampland animals was stressed, and man's responsibility as the gator's only natural enemy was discussed.

Lesson 6. This lesson, also in a written format, provided a bridge between the preceding lessons on the interrelationships in nature and subsequent lessons on manmade pollution. Its central theme was the value of our natural resources and how they had been abused. Respect for resources in our modern world was contrasted with that of the Native American. A variety of source materials was used in preparing this lesson.

Lesson 7. The visual component of this lesson was a Society for Visual Education filmstrip entitled The Air Pollution Menace. The text portion of the filmstrip was rewritten at the sixth grade vocabulary level. The filmstrip's central theme was that despite recent legislation, the air pollution problem continues to worsen.

Lesson 8. The lesson on ocean pollution was written utilizing various resource materials. The lesson demonstrated how the ocean's natural balance is upset by the dumping of sewage. The problems created by oil and chemical pollution, and the responsibility of industry were also discussed.

Lesson 9. The final lesson, entitled Peaceful Lake, was adapted from the Ecosystems curriculum developed by Science Curriculum Improvement Study. It was selected as the culminating leson because in presenting the history of Lake Erie (Peaceful Lake), this article tied together most of the major concepts of the ecology unit.

The lessons which included a film or filmstrip were presented to students in their regular classroom because they broke into treatment groups. All other lessons were presented to students after they had assembled in their respective treatment groups.

In addition to the materials outlined above, a set of 16 questions was developed for each lesson. These questions were to be used by the teacher during the discussion portion of the lesson and/or to be responded to in writing by the students. The types of questions and the criteria for their selection were discussed in the previous section under treatment conditions. A complete list of the questions for each lesson is contained in Volume II of this report.

Pilot Testing

The curriculum materials and the various treatment conditions for each lesson underwent two pilot tests. The first test was conducted in October 1973 in a school in San Francisco. It involved five of the lessons that ultimately were included in the study. The second test was conducted in January and February 1974 in Castro Valley, California and included all the lessons.

The pilot-testing had three purposes:

- to determine whether the reading level of the curricular materials was appropriate for sixth grade students;
- to test the clarity of the questions asked during the discussion portion of the treatment;
- to test the procedure of controlling number of probes and redirections versus the procedure of controlling total discussion time in the probing and redirection treatment.

The 12 students who participated in the first pilot test generally were one to two years behind in reading achievement. Eleven students were members of ethnic minority groups. The five lessons that were tested with them were presented on five consecutive days. The procedures employed required the students to read the curriculum selection silently, then follow along as the teacher (the Laboratory staff member conducting the piloting) read them. Visuals were used to illustrate some of the major concepts. Oral questioning followed. At the end of the five-lesson sequence, an oral post-test consisting of six higher cognitive questions was administered individually to each student. The outcomes of this pilot suggested that the reading level of the materials was too difficult and that a unit consisting of more than five lessons would be required if students were to develop skill in responding orally to higher cognitive questions.

The second pilot test was conducted in a sixth grade class in a school serving a suburban middle-class population. It involved all the lessons in the ecology unit including the warm-up lesson.

For this test, three groups of six students each were randomly selected from one classroom. Three teachers (Laboratory staff members) were assigned to teach the lessons, one to each group. Audiotape recordings were made of each discussion session so that the effectiveness of the semi-programmed questioning sequence and the use of probes and redirections could be studied in detail. An instructional strategy based upon a highly structured method of calling on students (one that controlled the number of times each student was called upon) also was tested.

The results of the second pilot indicated that the reading level of the materials was appropriate for students whose reading achievement was at, or near, the sixth-grade level. However, additional illustrative materials were needed, particularly charts and line drawings illustrating critical concepts in the units.

Review of the audio-recordings of the lessons suggested that the semi-programmed questions asked during the discussions were frequently too wordy and used vocabulary that was beyond the students' language level. It further suggested that exact control of the number of times a teacher probed and redirected created an unnatural situation, as did the structured method of calling on students. On the other hand, lack of exact procedures to follow in using probing and redirection resulted in considerable variation in the length of discussions both between teachers and between lessons. Attention and motivation problems associated with an imbalance in male-female group membership also were identified.

These findings led, first of all, to the equalizing of males and females (3+3) as much as possible within the treatment groups of Study I. Also, the semi-programmed discussion questions were rewritten using fewer words and simpler vocabulary. Charts and illustrations were added to the units. The sequence of the lessons was changed. The decision was made to provide some guidelines for the use of probing and redirection by indicating which questions should be probed and redirected and for how many times, but not designating which students should be asked to respond to these follow-up requests. At the end of this revision, the curriculum materials were judged to be ready for use in Study I.

STUDENTS AND TEACHERS

Students

In both Study I and Study II it was important to work with students who had sufficient reading skills to use the ecology unit materials effectively. The sixth grade, therefore, was selected as the grade level at which the study would be conducted.

Study I was conducted in the San Lorenzo Unified School District, San Lorenzo, California. Recruitment of the school sites included contact with the district administration followed by meetings with the elementary school principals to explain the nature of the study. Six principals offered to determine whether their sixth-grade teachers would agree to have their students participate. A total of 12 sixth-grade classes, two in each of six schools, volunteered. A total of 336 students from these classes served as the sample for the study.

Since the reading level of the students was considered important to the use of the curriculum materials, information was obtained concerning the students' scores on a state-administered reading test, the Comprehensive Tests of Basic Skills. This test was administered at the beginning of the school year in which the study was conducted. Table 5 presents the mean score and grade equivalent for all the students participating in the study.

TABLE 5

Study I

Mean Reading Scores of Students

VOCABULARY			COMPREHENSION			VOCABULARY PLUS COMPREHENSION		
$\overline{X}$	S.D.	Grade* Equiv.	$\overline{X}$	S.D.	Grade Equiv.	$\overline{X}$	S.D.	Grade Equiv.
27.42	(8.07)	5.3	27.85	(9.37)	5.1	55.27	(16.61)	5.2

* Grade equivalents obtained from Examiner's Manual, Comprehensive Tests of Basic Skills. Monterey, California: McGraw-Hill, 1968, pages 48-49.

While the average score for the students at the beginning of the year was below the sixth grade-level, it was determined that the students could be expected to read and understand the curriculum materials. The time period in which the study was conducted--March and April 1974--further contributed to this expectation since the students had completed an additional six months of schooling from the date of the state testing.

Teachers

A total of 12 teachers participated in Study I. These teachers were recruited from a group of 100 teachers selected at random from the substitute teacher list of the San Francisco Unified School District. Eleven of the teachers were female. Eleven were white. Their average years of teaching experience ranged from 0 to 7 years.

Procedures used to recruit and train the teachers are described below.

Recruitment. As was stated above, the teachers were recruited from among the substitute teachers in the San Francisco Unified School District.

Letters of invitation to serve as a teacher in the study were sent to the 100 teachers selected at random from the substitute list. Thirty-one responses were received. Each respondent was interviewed by two of the researchers on the study. Fifteen of these teachers were selected to receive training. The criteria for selection included: (a) possession of a California teaching credential, and (b) experience teaching children of upper-elementary age.

Training. A five-day training program was conducted. The purposes were to acquaint the teachers with the study, to introduce them to the various treatment formats, and to provide practice in conducting the various treatments.

The training began with a series of seminars conducted at the Far West Laboratory by the research staff. In these seminars the teachers were given an overview of the study. The various treatments were discussed in detail. The curriculum unit was explained. Aspects of skillful questioning were treated extensively, particularly those covered in Minicourses 1 and 9 (see Appendix A for an overview of these training programs). In addition, the teachers role-played the various discussion treatment formats until all felt comfortable conducting each treatment.

Following the seminars, three days of training were conducted in local schools which were not involved in the actual study. For the first two days the teachers worked in pairs. As one teacher conducted a discussion treatment format with a small group of six students (a condition similar to that included in the study), the partner recorded the lesson on a cassette recorder and took notes regarding the strengths and weaknesses of the lesson. These roles were switched after each lesson. At the end of each day, the audio recordings and notes were reviewed by the teachers and Laboratory staff to determine the correspondence of the lessons to the treatment conditions.

On the third day of work in the schools, the teachers worked individually as they would in the actual study.

The final selection of the 12 teachers for Study I was made on the basis of each teacher's ability to follow treatment guidelines while still maintaining a warm atmosphere in the discussion group. Effective use of the feedback techniques of probing and redirection also was a selection criteria.

Once Study I began, a refresher training session was held mid-way through the sequence of ten lessons to discuss ways to improve fidelity of treatments and ways to handle discipline problems.

The extent to which this training was effective is indicated by the fidelity of treatment information presented in the previous section.

INSTRUMENTATION

In order to study the effects of teacher use of probing and redirection upon student learning, two aspects of student performance were investigated. These were: (a) student achievement at both fact recall and higher cognitive levels and in terms of both written and oral modalities; and (b) student attitudes concerning the various treatment parameters. A total of seven achievement measures and six attitude measures were used in the study. Every student--irrespective of treatment--completed the same set of tests with the exception of the treatment-specific attitude scales. The particular version of these scales which was completed by the students depended on the treatment in which they participated.

Tables 6 and 7 list the achievement and attitude instruments, respectively. These tables also include the specific variables measured by each instrument and the point of administration in the study. Copies of each instrument are contained in Volume III of the report.

TABLE 6

Study I

Achievement Measures

INSTRUMENTS	VARIABLES MEASURED	POINT OF ADMINISTRATION	APPROXIMATE TESTING TIME[2]
Comprehensive Tests of Basic Skills-Reading	Vocabulary; Comprehension	Pre[1]	52 minutes
Ecology Information Test	Amount of information about ecology	Pre, post, delayed	15 minutes
Oral Test	Ability to state orally opinions, predictions, solutions, inferences, etc.	Pre, post	10 minutes
Essay Test	Ability to state in writing opinions, predictions, solutions, inferences, etc. Ability to state in writing reasons and if-then relationships.	Pre, post	25 minutes
Population Test	Ability to state in writing opinions, predictions, solutions, inferences, etc. Ability to state in writing reasons and if-then relationships.	Delayed	25 minutes
Question-Generating Test: Paper-and-Pencil Measure	Ability to generate questions. Quality of questions generated.	Pre, post	20 minutes
Question-Generating Test: Oral Measure	Ability to generate questions. Quality of questions generated.	Pre, post	2 minutes

1. Data collected by the participating school districts, not by the researchers.

2. These are average times for test administration. All tests except the Question Generating Test (Paper-and-Pencil Measure) were primarily power tests.

TABLE 7

Study I

Attitude Scales

SCALE	VARIABLES MEASURED	POINT OF ADMINISTRATION	APPROXIMATE TESTING TIME
Word Association Scale	Attitude toward ecological concerns	Pre, post	10 minutes
Gall-Crown Discussion Attitude Scale	Attitude toward class discussions Attitude toward thought questions	Pre, post	15 minutes
Ecology Unit Opinions	Attitude toward treatment group peers Attitude toward ecology teacher Attitude toward ecology curriculum	Post	15 minutes
Ecology Discussion Attitude Scale	Attitude toward discussion treatments Attitude toward thought questions in discussion treatments	Post	15 minutes
Written Exercise Attitude Scale	Attitude toward written exercises in the written exercise treatment	Post	15 minutes
Ecology Art Project Scale	Attitude toward art activities in the art activity treatment	Post	10 minutes

Achievement Measures

The seven achievement measures used in the study included one measure of general verbal ability and six measures of fact and higher cognitive outcomes related to the curriculum unit. A discussion of each of these instruments follows.

Comprehensive Tests of Basic Skills (CTBS). The verbal ability score from the Comprehensive Tests of Basic Skills (Form Q-Level 2) was used as a measure of the students' vocabulary and comprehension levels. These scores were obtained from the school district based upon the October, 1973 statewide testing program.

Two scales, Vocabulary (40 items) and Comprehension (45 items), from the reading section of the CTBS were used. The correlation between the Vocabulary and Comprehension scales for the student sample in Study I was .79. The correlations of the scales with other variables in the study are reported in Volume IV of this report. According to the test administrator's manual for the CTBS, the Kuder-Richardson 20 coefficients of internal consistency for the Vocabulary and Comprehension scales are .93 and .92, respectively. The errors of measurement for raw scores are 2.42 and 2.73, respectively.*

Ecology Information Test (EIT). The Ecology Information Test was designed to measure students' acquisition of factual information contained in the ecology curriculum. The test was constructed from a randomly drawn subset of facts obtained by a content analysis of the ecology curriculum unit and the semi-programmed questions included in the discussion treatments.

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* See Comprehensive Tests of Basic Skills, Technical Report, Page 32.

The EIT contains 27 multiple-choice (four alternative) items with directions to the student to select the "best" option. For Study I, these items were divided into two subtests. The Intentional Scale contains 10 items measuring students' ability to recall information covered in the semi-programmed questions asked by the teacher. The Incidental Scale measures students' recall of information not covered in the teacher's questions but included in other unit materials. Differential effects on these two types of items have been found consistently in research on prose learning (Anderson, 1975). Therefore, it seemed worthwhile to include them as separate dependent measures in this study.

It should be noted that the items in Intentional Scale I are "intentional" for the discussion and written exercise treatments, but "incidental" for the art activity treatment since this treatment did not receive questions of any type. The items in Incidental Scale I are "incidental" for all treatments.

The test was administered before, immediately after, and several weeks after the study treatments were completed in order to test both knowledge acquisition and retention.

The intercorrelations among the sub scales of the EIT are included in Table B-1, Appendix B, of this volume. Their correlations with other variables in the study and item statistics calculated separately for each treatment for pre, post, and delayed administrations are contained in Volume IV of this report. The item statistics include information concerning: (a) sample size, (b) item difficulty, (c) adjusted item difficulty calculated on the subset of students who answered the item, (d) point-biserial correlation of item scores with total scores,

(e) the number of items in each subtest, (f) mean test or subtest score, (g) standard deviation, (h) alpha coefficient, and (i) standard error of measurement.

The standard errors of measurement and internal consistency coefficients for the test as a whole and the subscales are reported in Table B-2, Appendix B for each administration within each treatment.

Oral Test (OT). The Oral Test measures students' ability to give plausible, reasoned oral responses to higher cognitive questions about the ecology curriculum.

The six higher cognitive questions in the test were representative of the question types used in the discussion treatments. Table 8 indicates the classification of each question in Bloom's Taxonomy and the derivation of each question from its treatment source. The items were constructed, pilot-tested, and revised as part of the pilot-testing of the curriculum (see previous section for explanation of this pilot test). Copies of the test, administration instructions, and the scoring manual are available in Volume III of this report.

The Oral Test was administered individually to each student. Students' responses were audiotaped to be rated later. The teachers hired for the study administered the test. For posttest administration, the teachers worked in classrooms in which they had not taught the unit in order to reduce bias due to teacher familiarity with students.

Each item in the Oral Test was scored by trained raters on two scales:

- content--the number of predictions, solutions, supported opinions, explanations, and inferences given by the student.
- logical extension--the number of "because" and "if-then" relationships supplied by the student.

TABLE 8

Study I

Derivation of Oral Test Items

ITEM NO.	CLASSIFICATION	TREATMENT AND/OR CURRICULUM SOURCE
2	Prediction	Incidental question (not included in any recitation treatment). Pertains to content of Lesson 7.
3	Solution	Modified version of a question which appeared in Lesson 1.
4	Explanation	Intentional question (included in all recitation treatments for Lesson 1).
5	Opinion	Intentional question (included in all recitation treatments for Lesson 8).
6	Opinion	Modified version of a question which appeared in Lesson 4.
7	Generalization	Incidental question. Pertains to content of Lesson 9.

The correlations between these variables and their correlations with other variables in the study are reported in Table B-3 (Appendix B), and in Volume IV, respectively.

Because of the nature of this instrument, two additional aspects of its administration and scoring must be considered. One is the procedures and interrater reliability for the rating of the audiotapes of students' responses. The second is the effects upon the ratings of cues on the tapes regarding the time of test administration.

Rating procedures. Six raters were trained to a satisfactory level of performance using a set of "training tapes." These raters then were randomly paired and each pair was randomly assigned a set of audiotapes to rate.

Interrater reliability was calculated by the intraclass correlation coefficient across all pairs of raters. Separate coefficients were computed for pre and post tapes for Study I and Study II. On the Content Scale, the coefficients ranged from .80 to .84, indicating high interrater agreement. For the Logical Extension Scale, in Study I, the pretape coefficient was .67. The posttape coefficient was .77.

Effects of cues. Although the raters at no time were told which classroom or treatment group they were rating, the audiotapes contained some statements by the tester that identified the point of administration. For example, a tester might remark, "Don't worry; you'll learn more about this later." Raters were instructed to note on their forms when such an indicator was present. The rating forms were analyzed to determine the frequency and distribution of these indicators. In Study I, indicators were relatively infrequent. Table 9 summarizes these data.

TABLE 9

Study I

Percentage of Oral Tests Having Pre-Post Indicator

TREATMENT	PERCENTAGE OF TESTS HAVING PRE-POST INDICATOR	
	Pre	Post
Probing and Redirection	0	18%
No Probing or Redirection	0	17%
Filler Activity	0	10%
Art Activity I	0	5%
Written Exercise	0	4%

A supplemental analysis was done to determine whether the indicators influenced raters to assign higher or lower scores than if the indicators had not been present. The analysis compared the raters' mean rating of indicator posttapes with their mean rating of non-indicator posttapes within the same treatment. The results are shown in Table 10. There are no significant differences in ratings based upon presence or absence of indicators. Furthermore, there are no consistent directional differences between the two conditions. Results of the Oral Test in Study I do not appear to have been affected by indicators on the audiotapes of point of administration of the test.

Essay Test. The fourth achievement measure was the Essay Test. The purpose of this test was to measure students' ability to give plausible, reasoned, written responses to questions about the ecology curriculum. The test contained only questions calling for more than simple recall of information. The derivation of the questions and their relation to

TABLE 10

Studv I

Comparison of Oral Test Posttest Ratings for "Post" Indicator Present versus "Post" Indicator Absent

VARIABLE	INDICATOR	PROBING AND REDIRECTION TREATMENT				NO PROBING AND RE-DIRECTION TREATMENT				FILLER ACTIVITY TREATMENT			
		No. of Tapes	$\overline{X}$ rating	S.D.	t*	No. of Tapes	$\overline{X}$ rating	S.D.	t	No. of Tapes	$\overline{X}$ rating	S.D.	t
LOGICAL EXTENSION SCALE	Present	10	4.00	2.79	0.59	6	3.25	2.34	0.08	6	3.50	2.55	0.52
	Absent	50	3.57	1.91		55	3.33	2.22		60	2.98	2.25	
CONTENT SCALE	Present	10	8.35	2.79	0.45	6	7.83	0.93	0.12	6	5.75	1.84	1.73
	Absent	53	8.76	2.59		57	7.69	2.68		62	7.65	2.59	

*t = 1.96, p ≤ .05

the curriculum are presented in Table 11. These questions also were constructed, pilot-tested and revised as part of the pilot-testing of the curriculum unit.

The Essay Test and the other free-response measures of higher cognitive processes (Oral Test and Transfer Test) were untimed to allow students sufficient opportunity to organize and communicate their ideas. Pilot testing was done to determine the amount of space on the test form which students needed in order to respond to each item in full. Students typically did not write essay-type responses to the questions, although given the opportunity to do so. Thus, the label "short-answer test" might be a more appropriate description of this measure than the label "Essay Test" by which it was designated in the study.

Because the test was long for some students, it was anticipated that they might respond better on items appearing early in the test relative to later items. Therefore, to control for item order effects, two forms of the test were constructed so that the item order was reversed on the second form. The different test forms were administered randomly to students.

The scoring of the Essay Test was in two steps. First, each response was judged to be relevant or not relevant to the question. Second, for the group of relevant responses, each response was scored by trained raters on two scales:

- content: the number of plausible predictions, solutions, supported opinions, explanations, and/or inferences provided.
- logical extension: the number of "because" and "if-then" relationships provided.

The correlations between each scale are presented in Table B-4 of Appendix B. Their correlations with other variables in the study are reported in Volume IV. Volume III contains a copy of the instrument and scoring procedures.

TABLE 11

Study I

Derivation of Essay Test Items

ITEM NO.	CLASSIFICATION	TREATMENT AND/OR CURRICULUM SOURCE
1	Generalization	Incidental question (not included in any discussion treatment). Pertains to content of Lesson 7.
2	Generalization	Modified version of a question which appeared in all discussion treatments for Lesson 7.
3	Generalization	Incidental question. Pertains to Lesson 8.
4	Opinion	Incidental question. Pertains to content of Lesson 5.
5	Interpretation	Intentional question for Lesson 4.
6	Solution	Incidental question. Pertains to content of Lesson 3.
7	Explanation	Incidental question for Lesson 7.
8	Opinion	Incidental question for Lesson 5.
9	Opinion	Modified version of a question which appeared in all discussion treatments for Lesson 6.
10	Prediction	Modified version of a question which appeared in all discussion treatments for Lesson 2.
11	Solution	Incidental question for Lesson 1.
12	Opinion	Incidental question. Pertains to content of Lesson 1.

Five raters scored the Essay Test. Interrater reliability calculated by the intraclass correlation coefficient across all pairs of raters for both Study I and Study II was high for the Content Scale, ranging from .86 to .90. In Study I the coefficients for the Logical Extension Scale were .70 for the pretest and .72 for the posttest.

Because the pairs of raters were assigned test folders containing all the pretests or posttests for a particular classroom, it was important to check for a rater-by-classroom interaction based upon possible leniency on the part of some rater-pairs. The presence of this interaction was tested by analyzing a randomly drawn subset of 20 tests which the five raters had scored independently during refresher training. Their mean ratings on the Content Scale and the Logical Extension Scale were compared using a one-way analysis of variance. The F values for the Content Scale (F=.94), and the Logical Extension Scale (F=.79) did not reach statistical significance.

Transfer (Population) Test. The purpose of the Transfer Test was to determine whether higher cognitive response skills would transfer to a new, unstudied curriculum topic. The chosen topic was the problem of human population explosion.

The test consisted of nine higher-cognitive questions for which students wrote brief essay answers. The questions were representative of the types of higher cognitive questions used in the discussion treatments. Three questions solicited a supported opinion, two solicited a prediction, two an explanation, one a solution, and one an interpretation.

The scheme for scoring this test was similar to that used for the Oral and Essay Tests. The correlation between the Content and Logical Extension Scales was .65 in Study I. Correlations with other variables in the study are reported in Volume IV. Volume III contains a copy of the instrument and the scoring procedures.

Interrater reliability for scoring this test was high: .87 for the Content Scale and .86 for the Logical Extention Scale. No significant rater-by-classroom interaction was found. F values for a one-way analysis of variance based upon mean ratings of 20 randomly selected tests which the five raters had scored independently during refresher training are Content Analysis, F=.09, and Logical Extension, F=.15.

Question-Generating Test (Paper and Pencil). The question-generating test asks students to generate as many questions about pollution and wildlife as they can in twenty minutes (ten minutes for each topic). It was administered in two forms--the paper and pencil version discussed here and the oral version, the discussion of which follows in the next section.

Scores on this test were used to test whether the models of questioning presented by the teachers in the various treatments influenced students' question-generating behavior.

The tests were scored independently by two raters on the following variables:

- Number of non-pertinent questions, that is, questions which did not relate to pollution or wildlife.
- Number of pertinent questions, that is, questions which related directly to pollution and wildlife.
- Quality rating. Each pertinent question was rated on a three-point quality scale. Common fact questions were rated "1," common higher cognitive questions were rated "2," and original higher-cognitive questions were rated "3."
- Number of Specific Questions. Each pertinent question was rated according to whether or not it referred to a specific aspect of pollution of wildlife.
- Number of Requests for Rationale. The sum of "Why?" "Why, or why not?" "Explain," or similar statements which followed questions.

A copy of the test and scoring manual are presented in Volume III of the report. The intercorrelations between the five scales are shown in Table B-5 of Appendix B of this volume. Their correlations with other variables in the studies are reported in Volume IV. Intraclass correlations for reliability of the rating across all pairs of raters also are reported in Table B-6 of Appendix B.

Question Generating Test (Oral). The oral question generating test was similar to the written version except that a different set of questions was asked orally and the responses were given orally. These questions were asked and audiotaped at the same time as the administration of the Oral Test (see p. 46). Each audiotape was rated for frequency of nonpertinent and pertinent questions and for overall quality using the same criteria used in the paper-and-pencil version.

Interrater reliability based upon intraclass correlation coefficients across all raters ranged from .84 to .92 for pertinent questions; .80 to .86 for quality rating; and .62 for non-pertinent questions on the pretest and .83 for the posttest tapes.

Correlations between the variables measured by this test are presented in Table B-7 of Appendix B. Correlations with other variables in the study are in Volume IV. A copy of the test and scoring manual are presented in Volume III of the report.

As with the Oral Test, the appearance of "post" indicators on the audiotapes also might bias the ratings on this test. However, Table 12 indicates that the Study I data were not influenced by this factor.

TABLE 12

Study I

Comparison of Question-Generating Test (Oral) Posttest Ratings for "Post" Indicator Present versus "Post" Indicator Absent

		Probing and Redirection Treatment				No Probing and Redirection Treatment				Filler Activity Treatment			
VARIABLE	INDICATOR	No. of Tapes	$\overline{X}$ rating	S.D.	t*	No. of Tapes	$\overline{X}$ rating	S.D.	t	No. of Tapes	$\overline{X}$ rating	S.D.	t
NON-PERTINENT QUESTIONS	Present	10	0.30	0.95	0.14	6	0.08	0.20	0.10	6	0.00	0.00	0.70
	Absent	52	0.34	0.78		56	0.10	0.48		62	0.11	0.38	
PERTINENT QUESTIONS	Present	10	1.30	1.18	0.19	6	2.08	1.11	0.57	6	1.33	1.75	0.51
	Absent	52	1.39	1.35		56	1.78	1.22		62	1.65	1.40	
QUALITY RATING	Present	10	1.04	0.80	1.18	6	1.28	0.75	1.22	6	0.75	0.82	0.75
	Absent	52	0.76	0.65		56	0.97	0.56		62	0.96	0.63	

*t = 1.96, $p \leq .05$

Attitude Scales

Six attitude measures were used in the study. Three of these measures were administered to all of the students regardless of the treatment group to which they were assigned. The other three measures were related to students' attitude toward the specific treatment in which they participated.

Word Association Scale. The Word Association Scale measured students' attitudes toward the major ecological topics covered in the ecology curriculum unit. It was administered to all students pre and post treatment.

The scale dealt with attitudes toward the topics: balance of nature, ecology, alligators, wolves, air pollution, and water pollution. Ten bi-polar adjectives from the evaluative factor (Osgood, Suci, & Tannenbaum, 1957) were applied to each topic. Students indicated their attitude on each scale by marking on a seven-point scale anchored by the evaluative descriptors. The scales for four topics were scored so that a positive ecological attitude was represented by a high score. For two topics (air pollution and water pollution), the scoring was reversed so that a high score indicated a negative attitude. It should be noted, however, that the bi-polar scales of important-unimportant and interesting-dull were not reversed on these topics since it was thought that students might have a negative attitude toward pollution, yet find it interesting and important.

A copy of the Word Association Scale, scoring keys, and item statistics are contained in Volume III.

The intercorrelations of the scales, and the internal consistency coefficients and standard errors of measurement for each scale for each treatment are reported in Tables B-8 and B-9, respectively, of Appendix B. Their correlations with other variables in the study are presented in Volume IV.

Gall-Crown Discussion Attitude Scale (GDAS). The GDAS measured students' attitudes toward: (a) class discussions in general, and (b) questions calling for responses more complex than simple recall. It was administered to all students pre and delayed.

The GDAS consisted of two subscales: one of 19 items measuring attitude toward discussion; the other of 11 items measuring attitude toward higher cognitive questions. All items used a four-point Likert response format and were randomly ordered. Each subscale contained both positive and negative items to avoid the problem of an acquiescent response set.

As with the other instruments, the intercorrelations of the scales and the alpha coefficients and standard errors of measurement are reported in Tables B-10 and B-11 of Appendix B. Volume III contains a copy of the scale, scoring keys, and item statistics. Volume IV reports correlations of the scale with other variables in the study.

Ecology Unit Opinion Scale (EUOS). The EUOS measured students' attitudes toward other students in the treatment group (5 items), attitude toward the ecology teacher (16 items), and attitude toward the ecology curriculum (9 items). It was administered to all students regardless of treatment as a post measure only.

Items in this scale also use a four-point Likert response format and are randomly ordered. The various statistics related to the instrument are reported in Tables B-12 and B-13 of Appendix B and Volume IV. Copies of the scale, scoring keys, and detailed item statistics are contained in Volume III.

Ecology Discussion Attitude Scale (EDAS). This instrument relates only to those treatments in which students participated in group discussions. It measures students' attitudes toward: (a) the discussion process used in the treatments, and (b) questions requiring higher cognitive responses.

The items in this scale parallel items from the GDAS in order to facilitate comparisons between the scales. The two subscales contained a like number of items as the subscales in the GDAS--19 items related to discussion, 11 items related to higher cognitive questions. A four-point Likert response format was used. Items were randomly ordered in the complete instrument and each subscale contained a mixture of positive and negative items.

Refer to Tables B-14 and B-15 of Appendix B of this report, Volume III for a copy of the instrument, and Volume IV for technical statistics regarding the instrument.

Written Exercise Attitude Scales (WEAS). The WEAS was administered only to the students in Study I who completed the written exercise treatment. It measured students' attitudes toward: (a) completing written exercises; and (b) written questions requiring higher cognitive responses.

The WEAS contains two subscales--12 items related to written exercises, 11 items related to thought questions. All items use a four-point Likert response format and are randomly ordered in the complete instrument. Each subscale contains a mixture of positive and negative items. The intercorrelation between the two subscales was .76. For the Attitude Toward Written Exercises subscale, the coefficient of internal consistency (alpha) was .88 and the standard error of measurement was 2.55. For the Attitude Toward Thought Questions subscale, the internal consistency coefficient (alpha) was .86 and the standard error of measurement was 2.48.

Ecology Art Project Scale (EAPS). This scale was administered as a post measure to only those students in the art activity treatment.

It measured students' attitude toward the art activities. It consisted of 19 four-point Likert items with a mixture of positive and negative items. See Table B-16 of Appendix B in this report and Volumes III and IV for further technical information regarding the instrument.

RESEARCH DESIGN

The primary purpose of Study I was to test the effects of four different instructional treatments (probing and redirection, no probing and redirection, filler activity, and art activity) on student achievement and attitudes. A fifth treatment (written exercise treatment) was provided for those pupils in each classroom who were not included in the research design.

The nature of the discussion treatments precluded use of a factorial experimental design in which the factors of ecology teacher and treatment would be crossed. Since each ecology teacher could instruct only four treatment groups during a school day, the cell size in a factorial design would have been limited to two cases.* While the experiment could have been replicated to gain statistical power from a larger sample, this had several disadvantages: logistically, it would have been difficult to achieve; also, the possible effects of teaching practice and time of year would have been uncontrolled and difficult to measure.

Another concern was whether a crossed-effects design would achieve the research objectives. Such a design is uniquely appropriate for investigating interactions between main effects. However, since the ecology teachers were to be trained to follow a prescribed set of treatments, it did not seem likely that there would be teacher by treatment interactions. Therefore, it seemed appropriate to use a Latin square design, which does not allow for investigation of interaction effects, but which provides the flexibility needed to accommodate the parameters of the discussion treatments.

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* We are assuming here that the group of N=6 rather than the individual student is the statistical unit of analysis. For further discussion of this point, see the Results Chapter.

Latin square designs are not frequently encountered in educational research though they provide very efficient tests of certain types of hypotheses. The term "Latin square" comes from an ancient puzzle that deals with the number of different ways Latin letters can be presented in a square (matrix) such that each letter appears once, and only once, in each column and in each row.

Latin square designs are employed in experiments that meet, in addition to the general assumptions of the analysis of variance model, other conditions that include:

- random assignment of treatment to the experimental units within each row and column with each treatment appearing only once in a row and once in a column;
- the number of rows, columns, and treatments must be equal;
- it is assumed that there are no interactions among rows and columns.

To meet these conditions, each classroom used in Study I was randomly subdivided into four groups of six students (with the restriction that the number of boys and girls should be equal in each subgroup). Each of the four instructional treatments was assigned at random to one of the four subgroups within each classroom; thus, a comparison of treatments within each classroom was possible. Since the instructional treatments were carried on simultaneously within each classroom, four different ecology teachers were assigned to a classroom, one to each treatment subgroup. Teachers and classrooms were blocked into groups of four and teachers were assigned to treatment groups within classrooms in a Latin square design so that in a block of four classes each teacher taught each instructional treatment once. In both Study I and Study II, this basic Latin square was repeated three times. Thus, there were 12 classrooms per study, four for each of the three Latin squares and there were also 12 ecology teachers, four assigned to each Latin square.

Thus, in each study three Latin squares such as that displayed in Table 13 were formed.

TABLE 13

Studies I and II

Latin Square Design

Classroom	Teacher			
	E1	E2	E3	E4
C1	T1	T2	T3	T4
C2	T2	T3	T4	T1
C3	T3	T4	T1	T2
C4	T4	T1	T2	T3

C = Classroom
E = Ecology Teacher
T = Treatment

Since most classrooms in the experiment had more than 24 pupils, a fifth treatment (Written Exercise) was provided for the remaining students. The data from the written exercise groups were not part of the Latin square design and were examined ad hoc.

Assignment of Schools and Classrooms

Study I was conducted in a single school district using two sixth-grade* classrooms from each of six schools. Characteristics of the school district and the students were discussed earlier in this chapter (see pages 37 to 40).

The composition of the three Latin squares in Study I is given in Table 14.

Logistic constraints dictated that each group of four ecology teachers be assigned to teach two classrooms at the same school in the morning, and two other classrooms at a second school in the afternoon. After these arrangements had been made, each Latin square was formed by pairing a "morning" school with the "afternoon" school geographically nearest to it. Table 14 reflects this arrangement by showing that each Latin square consists of a "morning" and an "afternoon" school. The table also shows the approximate time of day during which each classroom was provided instruction. Assignment of schools and classrooms to Latin squares was not random. However, the assignment procedure was not expected to significantly bias the learning outcomes.

Assignment of Teachers to Latin Square Blocks

Twelve ecology teachers were randomly assigned to the three Latin squares. A different group of ecology teachers taught the written

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* One classroom included both fifth and sixth-grade pupils.

TABLE 14
Study I
Composition of Squares

SQUARE 1

ECOLOGY TEACHER	SCHOOL 1		SCHOOL 2	
	9:20AM*Class 1	10:30AM Class 2	12:30PM Class 3	1:30PM Class 4
1	Treatment 1 B=3 G=3	Treatment 3 B=3 G=3	Treatment 2 B=3 G=3	Treatment 4 B=2 G=4
2	Treatment 2 B=3 G=3	Treatment 4 B=3 G=3	Treatment 1 B=3 G=3	Treatment 3 B=3 G=3
3	Treatment 4 B=3 G=3	Treatment 1 B=3 G=3	Treatment 3 B=3 G=3	Treatment 2 B=3 G=3
4	Treatment 3 B=3 G=3	Treatment 2 B=3 G=3	Treatment 4 B=2 G=4	Treatment 1 B=3 G=3
13	Treatment 5 B=5 G=3	Treatment 5 B=4 G=1	Treatment 5 B=0 G=3	Treatment 5 B=0 G=3

SQUARE 2

ECOLOGY TEACHER	SCHOOL 3		SCHOOL 4	
	9:20AM Class 5	10:30AM Class 6	12:30PM Class 7	1:30PM Class 8
5	Treatment 3 B=3 G=3	Treatment 2 B=3 G=3	Treatment 1 B=3 G=3	Treatment 4 B=3 G=3
6	Treatment 4 B=3 G=3	Treatment 1 B=3 G=3	Treatment 2 B=3 G=3	Treatment 3 B=3 G=3
7	Treatment 1 B=3 G=3	Treatment 4 B=3 G=3	Treatment 3 B=3 G=3	Treatment 2 B=3 G=3
8	Treatment 2 B=3 G=3	Treatment 3 B=3 G=3	Treatment 4 B=3 G=3	Treatment 1 B=3 G=3
15	Treatment 5 B=4 G=4	Treatment 5 B=5 G=5	Treatment 5 B=1 G=5	Treatment 5 B=3 G=2

SQUARE 3

ECOLOGY TEACHER	SCHOOL 5		SCHOOL 6	
	9:20AM Class 9	10:30AM Class 10	12:30PM Class 11	1:30PM Class 12
9	Treatment 2 B=3 G=3	Treatment 3 B=3 G=3	Treatment 1 B=3 G=3	Treatment 4 0
10	Treatment 4 B=3 G=3	Treatment 1 B=3 G=3	Treatment 3 B=3 G=3	Treatment 2 B=2 G=4
11	Treatment 1 B=3 G=3	Treatment 2 B=3 G=3	Treatment 4 B=3 G=3	Treatment 3 B=2 G=3
12	Treatment 3 B=4 G=3	Treatment 4 B=4 G=3	Treatment 2 B=3 G=3	Treatment 1 B=3 G=3
14	Treatment 5 0	Treatment 5 0	Treatment 5 B=3 G=2	Treatment 5 0

* Times are approximate

Treatment 1 = Probing and Redirection
Treatment 2 = No Probing and Redirection
Treatment 3 = Filler Activity
Treatment 4 = Art Activity I
Treatment 5 = Written Exercise
B = Boys
G = Girls

exercise treatment. The 12 teachers were not randomly assigned to squares or classroom; nor were the teachers handling the written exercise treatment randomly assigned to classrooms. Rather these assignments depended on each teacher's time available for participation in the study and on logistical considerations.

Assignment of Treatments to Ecology Teachers

After the 12 ecology teachers were assigned to squares, they were randomly assigned to cells within the square. This assignment specified the order in which they taught the four treatments in the four classrooms during the school day. The Latin square configurations were randomly created so that each ecology teacher taught each treatment over the course of the school day, and so that each treatment was present in each classroom.

Assignment of Students to Treatments

Since treatment groups with an approximately equal number of boys and girls were judged desirable, each class was stratified with respect to sex of student. Boys were randomly assigned to discussion and art activity treatment groups until there were three boys in each group. The same procedure was used to assign girls to treatments.

In a few classrooms the procedure could not be used as planned. For example, Classroom 12 was a combination fifth-sixth grade class with only 17 sixth-graders. The inadequate number of sixth graders (24 sixth-graders were needed to form four groups of six students for the four treatments) created a "hole" in the Latin square design. The 17 students were randomly assigned to the discussion treatments only (see Table 14). The estimation procedures used to accommodate the missing data in the art activity treatment are described in the "Analysis" section of this report.

Because of the researchers' commitment to the school district to provide every student with a learning experience, fifth graders were assigned to the art activity treatment but were not included in the data analyses.

As shown in Table 14, two classrooms did not have sufficient numbers of boys or girls to create equal sex distributions in each of the treatment groups. In classrooms 9 and 10, the randomization procedures would have resulted in a single student in each group being assigned to the Written Exercise treatment. To prevent this awkward situation, these students were reassigned to the Art Activity treatment. Consequently, classrooms 9 and 10 each had seven students in this treatment.

The final procedure in assigning students to treatments was to check with the students' regular teacher to determine whether a treatment group contained students who were highly disruptive when placed in proximity to each other. Also, teachers were asked if the students assigned to the written activity treatment included any students whose writing skills would render the treatment meaningless or obviously ill-adapted to these students. Such students were randomly reassigned to another treatment. Each reassigned student was replaced by a student from that treatment in order to keep the design balanced. The frequency of reassignments was low, on the average about one per classroom.

STATISTICAL ANALYSIS

Adjustment Procedures

To insure that observed differences between treatment groups on post and delayed measures were not due to pre-experimental differences in students' ability, students were randomly assigned to treatments within each classroom. To provide additional assurance that pretreatment differences did not contribute to posttreatment differences, each dependent variable was examined for the possibility of adjusting for pre-experimental differences before performing the analyses of variance.

The decision to use adjusted post or delayed treatment scores was subject to two conditions. Adjusted scores add little to the precision of analyses unless the correlation between the variable to be adjusted and the adjusting variable is greater than .30 (Elashoff, 1969). Hence, the first condition to be satisfied in using a variable to adjust a posttreatment measure was that its correlation with the posttreatment measure be greater than .30.

The second concern in choosing adjusting variables was whether the usual assumptions for analysis of covariance were justified. These assumptions are that:

(a) the relationship between the adjusting variable and posttreatment variable is linear within each lesson group (linearity),

(b) the posttreatment scores are normally distributed about the regression line and their variance about the line is a constant independent of the adjusting variable (normality and within group homoscedasticity),

(c) the regression slopes of posttreatment scores on adjusting variable scores are parallel for all lesson groups (homogeneity of regression),

(d) the variance of posttreatment scores about the regression line is equal in all lesson groups (homoscedasticity across groups).

The validity of these assumptions ideally would be tested by examining these conditions within each group of students who experienced the experimental treatments, i.e., lesson groups. This approach was precluded since there were only six students in each lesson group in both Study I and Study II. Therefore, in order to obtain a sufficient sample size, the assumptions for analysis of covariance were tested by examining the regression of individuals' posttreatment scores on individuals' scores on the adjusting variable by collapsing over classrooms within a single treatment condition. If the F-test for homogeneity of regression was significant at the 5 percent level or if other assumptions appeared to be unjustified in visual inspections of scatterplots, the posttreatment scores on that variable were not adjusted. Generally, these latter assumptions were unjustified for measures which were characterized either by a large number of zero scores or by a large number of maximum scores on pretreatment or posttreatment variables. The adjustment method employed here was intended to give a good approximation of covariance adjustment. Small size (N=6) precluded the use of true covariance adjustments.

Several variables could be considered as logically valid adjusting variables for a given post or delay measure. In the interests of parsimony and ease of interpretation, the most desirable choice for an adjusting variable is the pretest corresponding to the posttreatment measure. For cases in which the pretest variable failed to satisfy selection conditions at either stage, total reading score was examined as a possible adjusting variable. Because of the difficulty of satisfying both decision conditions when both pretest and total reading score were used jointly as adjusting variables, and because using multiple variables to adjust posttreatment scores was judged likely to cloud interpretations, only one variable was used to adjust posttreatment scores. For those variables which were adjusted, the following relation was used:

$$\overline{Y}_i \text{ (adj)} = \overline{Y}_i - b_p (\overline{X}_i - \overline{X}),$$

where: $\overline{Y}_i$ (adj) is the adjusted cell mean on the posttreatment variable,

$\overline{Y}_i$ is the unadjusted or original cell mean on the posttreatment variable,

$\overline{X}_i$ is the cell mean for the corresponding adjusting variable,

$\overline{X}$ is the mean of all cells regardless of treatment on the adjusting variable, and

b_p is the pooled estimated of the regression slope.

The adjusted lesson group or cell means were used in the analysis of variance in the same way as cell means for those variables which were unadjusted. Table 15 presents the information used to choose adjusting variables for posttreatment variables and the pooled slope estimated for those posttreatment variables which were adjusted.

Unit of Analysis

The unit of analysis chosen for both Study I and Study II was the discussion/lesson group; more specifically, the mean of student scores on any given variables within a discussion/lesson group; in other words, the mean of scores for the students within each cell of each Latin square presented in Table 14. Thus, the basic data were the mean of the 12 groups experiencing each treatment. Within each square, each of the four treatments was assessed in four classrooms. The sample size per square, therefore, was the 16 cell means in that square. With three replications of each Latin square, the total sample size for the study would be 48 cell means. However, the sample size for Study I was only 47 cell means due to the impossibility of forming four subsets of six sixth-graders from one grade-mixed classroom containing only 17 sixth-grade students. Procedures used to handle the missing data for the forty-eighth cell are discussed later in this section.

TABLE 15

Study I

Summary of Statistics Used in Adjusting Posttreatment Variables

DEPENDENT VARIABLE	ADJUSTING VARIABLE	F FOR PARALLELISM OF REGRESSION	r	b_p
		$F_{1,\infty} = 2.60$		
Ecology Information Test:				
Intentional Scale I, Post	Total Reading	1.70	.65	.09
Incidental Scale I, Delay	Total Reading	0.77	.52	.10
Oral Test:				
Content Scale, Post	Pre	0.66	.60	.65
Essay Test:				
Content Scale, Post	Pre	1.62	.72	.69
Transfer Test:				
Content Scale, Delay	Essay Content Pre	.26	.60	.55
Written Question-Generating Test:				
Pertinent Questions, Post	Pre	.93	.61	.59
Quality Rating, Post	Pre	2.08	.45	.45
Word Association Scale:				
Wolf, Post	Pre	.60	.51	.54
Alligator, Post	Pre	2.13	.45	.46
Water Pollution, Post	Pre	1.17	.47	.40
Gall-Crown Discussion Attitude Scale:				
Thought Questions, Post	Pre	1.30	.52	.60
Discussions, Post	Pre	.80	.60	.66

Computation of Analysis of Variance

Computations were performed using the computer program BMDX64 (Dixon, 1973). Each of the main factors--treatment, classrooms, teachers, and Latin squares--was considered as a fixed effect in partitioning the total variance into main effects for treatments, classrooms within Latin squares, teachers within squares, squares, a treatment by square interaction, and a residual (error) term. Since the unit of analysis is the discussion/lesson group mean, the within group variance cannot be used to provide an error term. The Latin square design is not a complete factorial and only one classroom subgroup is used for each treatment-teacher combination. Thus, the residual term is a pooled estimate of between group variance composed of all the possible interaction terms except the estimable treatment by square interaction. The validity of this analysis rests on the assumption that the unknown interactions are negligible with respect to the identifiable effects.

Multiple Dependent Variables

It should be noted that testing a large number of univariate hypotheses concerning correlated dependent variables, in this case correlated because the different measures were obtained from the same students, increases the probability of a Type I error for any single hypothesis. For example, in testing 20 independent hypotheses at a 5 percent level of significance, one statistically significant difference by chance alone might be expected. Since the measures in this study are correlated, patterns of all treatment effects significant or all treatment effects insignificant are more likely than if the measures were independent. Thus, the reader is cautioned to view the tests of significance as signals that potentially reliable differences between treatments were observed. The interpretation of results will depend heavily on examining the size and patterning of differences among treatments as well as considering whether treatment differences are consistent within conceptually meaningful clusters of dependent variables.

A formal method of combining results across dependent variables and maintaining a fixed significance level for the combined analysis would be to use a multivariate analysis of variance. However, multivariate procedures were not used in this study because of the small number of degrees of freedom for error, the decreasing robustness of analysis of variance as dependent variables are added, and the increased difficulty in making interpretations of the results.

Missing Data

Two types of "missing" data are present in this analysis--unequal class sizes and the empty cell previously discussed. Unequal classes were simply ignored in this analysis. The missing cell mean was estimated by a full least squares solution where each effect was treated as entering last. Treatment means were calculated from the estimated treatment effects. They are not the simple means.

Omega Squares

Omega squares (Hays, 1965; Glass & Hakstian, 1969) were calculated. These statistics provide an estimate of the strength of association between variables (as a percent of variance) and may be helpful in the interpretation of results. Omega squared is very dependent on exact design and the treatments included.

Planned Comparisons

In addition to examining the data for overall treatment differences, several questions pertaining to differences between treatment groups were of interest. Specifically, in Study I the following planned comparisons of treatment differences were examined on all dependent variables:

(a) probing and redirection versus no probing and redirection,

(b) no probing and redirection versus filler activity, and

(c) the recitation treatments as a whole (probing and redirection, no probing and redirection, and filler activity) versus art activity.

Each planned comparison had one degree of freedom and was tested for significance using the mean square error term from the analysis of variance. For those dependent variables which were adjusted, the comparisons used adjusted cell means.

Summary

The results reported in the following chapter are based upon a Latin square design. Adjustments for pre-existing differences in cell means were made using estimated analysis of covariance adjustments where reasonable. Missing data were estimated by a full least squares solution. Several planned comparisons as well as main effects were tested. Computations were performed using computer program BMDX64.

CHAPTER FOUR

STUDY I RESULTS

The statistical analyses for Study I were planned in response to three research objectives:

1. to determine what student learning outcomes are affected by presence or absence of probing and redirection in discussions;
2. to determine what student learning outcomes are affected by presence or absence of discussions; and
3. to determine the relative effect on student learning of teachers' questions delivered in discussions compared with the same questions presented and answered in written format.

Five instructional treatments were designed to investigate these effects. These included three discussion treatments, an art activity treatment, and a written exercise treatment. In the probing and redirection discussion treatment, twelve groups of students participated in discussions in which their ecology teacher probed and redirected the students' answers to prespecified questions. In the no probing and redirection discussion treatment, twelve groups of students participated in discussions in which the same prespecified questions were asked, but none of the students' answers were probed or redirected. The filler activity discussion treatment was identifical in format to the no probing and redirection treatment except that a filler activity was added after each discussion to equate it in length to the probing and redirection treatment. Twelve groups of students also participated in the filler activity treatment. In the art activity treatment, eleven groups of students participated in curriculum-related art activities with no discussion. Finally, in the written exercise treatment, nine groups of students responded to the same prespecified questions as in the discussion treatments, except that the questions were presented and answered in written format.

The treatments were administered within a Latin square design by fifteen ecology teachers* to twelve sixth-grade classes in a single school district. Each student was administered a test battery before, immediately after, and/or two weeks after the treatments to determine the effects of the treatments on achievement and attitudes related to the specific curriculum which they had studied.

In the following section the data for each test variable are examined by analysis of variance methods to test statistical significance of the overall treatment effect. The treatment group (usually six students) rather than the individual student was used as the unit of analysis.

Following the analysis of variance for treatment main effects, planned comparisons of treatment means for each dependent variable are presented. The purpose of these comparisons is to determine the statistical significance of the following differences:

1. The difference between the probing and redirection treatment mean and the no probing and redirection treatment mean for each outcome variable. This analysis is designed to determine whether certain outcome variables are affected by the presence of probing and redirection techniques in discussion.

2. The difference between the no probing and redirection treatment mean and the filler activity mean on each outcome variable. This analysis is designed to determine whether observed differences on outcome variables between the probing and redirection treatment and the no probing and redirection treatment, if any, can be explained by the treatment differences in time on task.

3. The difference between the three combined discussion treatment means and the art activity mean on each outcome variable. The purpose of this analysis is to determine whether certain outcome variables are affected by opportunity to participate in discussion following initial reading/viewing of curriculum material.

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* Twelve of the ecology teachers administered each of the discussion treatments and the art activity treatment. The three remaining teachers administered the written exercise treatment.

The final planned comparison involves the difference between the written exercise treatment mean and each of the other treatment means for each of the outcome variables. The analysis of variance design used here does not permit the usual tests of statistical significance of differences in this particular instance. Instead, each of the discussion and art activity means are examined to determine whether they fall above or below the 95 percent confidence limits for the corresponding written exercise treatment mean.

A discussion of other effects examined by the analysis of variance follows the planned comparisons. These include class, ecology teacher, and Latin square effects, and treatment by Latin square interactions.

For ease of interpretation the results are organized into three main sections. First, the achievement test data are discussed in terms of (1) treatment main effects, (2) planned comparisons of treatment means, and (3) other analysis of variance effects. Next, the analyses of attitude scale data are discussed under the same headings. Finally, the status variables of verbal ability and session attendance are discussed in the context of their possible influence on treatment differences.

Cell means used in the analyses are reported in Appendix D of this volume.

ACHIEVEMENT MEASURES

Table 16 presents the results of the analysis of variance for the ability, achievement, and attendance measures. A relatively detailed description of this table is presented below to insure that all information of value can be easily obtained from it.

The leftmost column lists the names of the dependent variables. Each row of the table corresponding to the variable named presents information pertaining to that variable only.

TABLE 16

Study I
Analysis of Variance Summary for
Measures of Ability, Achievement, and Attendance

DEPENDENT VARIABLE	ADJUSTING VARIABLE	MS error df=17	F VALUES AND ω^2 FOR ANALYSIS OF VARIANCE EFFECTS: Treatment		Class		Teacher		Square		Treatment by Square	
			$F_{3,17}$	ω^2	$F_{9,17}$	ω^2	$F_{9,17}$	ω^2	$F_{2,17}$	ω^2	$F_{6,17}$	ω^2
STATUS VARIABLE												
Number of Sessions Attended		0.55	1.74	0.06[a]	0.48	0.12	0.68	0.07	0.56	0.02	0.88	0.13
CTBS[b] - Total Reading		61.14	2.31	0.06	1.82	0.12	0.93	0.01	3.36	0.07	1.13	0.01
KNOWLEDGE VARIABLES												
Ecology Information Test:												
Intentional Scale I, post	total rdng	0.85	5.04*	0.20	2.53*	0.22	0.46	0.00	0.35	0.00	0.26	0.00
Intentional Scale I, delay		1.12	6.90*	0.19	3.19*	0.21	1.09	0.01	2.44	0.03	1.73	0.05
Incidental Scale I, post		2.52	3.07	0.12	1.61	0.10	1.20	0.03	0.06	0.01	0.87	0.21
Incidental Scale I, delay	total rdng	2.46	1.06	0.00	2.38	0.25	0.21	0.00	0.61	0.00	0.69	0.00
HIGHER COGNITIVE VARIABLES												
Oral Test:												
Content, post	pre	1.08	6.83*	0.30	0.64	0.00	0.94	0.00	0.62	0.00	0.74	0.00
Logical Extension, post		1.49	3.05	0.10	1.55	0.08	1.27	0.04	2.12	0.04	0.75	0.00
Essay Test:												
Content, post	pre	1.92	3.13	0.08	3.24*	0.22	0.37	0.03	2.10	0.16	0.53	0.03
Logical Extension, post		0.28	5.37*	0.13	5.67*	0.41	0.75	0.00	0.16	0.00	1.58	0.03
Transfer Test:												
Content, delay	essay pre	1.71	3.42*	0.07	3.27*	0.32	1.28	0.00	8.79*	0.10	1.43	0.09
Logical Extension, delay		0.26	3.05	0.05	5.55*	0.35	1.41	0.03	11.58*	0.18	0.93	0.00
QUESTION-GENERATING VARIABLES												
Written Question Generating Test:												
Non-pertinent Questions		0.12	5.12*	0.09	7.80*	0.42	1.69	0.04	9.65*	0.12	1.21	0.01
Pertinent Questions	pre	44.69	1.05	0.00	5.62*	0.43	0.76	0.00	4.09*	0.06	1.84	0.05
Specific Questions		8.69	3.17	0.06	3.62*	0.22	2.48	0.13	2.93*	0.07	2.98*	0.11
Request for Rationale		0.13	2.05	0.08	30.05*	0.02	5.32*	0.04	9.80*	0.31	6.99*	0.18
Quality Rating	pre	0.68	3.23*	0.07	4.61*	0.32	0.60	0.00	6.09*	0.10	2.47*	0.00
Oral Question Generating Test:												
Non-pertinent Questions		0.06	3.38*	0.16	0.47	0.10	1.11	0.02	0.77	0.00	0.33	0.00
Pertinent Questions		0.35	1.45	0.03	1.59	0.11	1.14	0.03	0.58	0.02	0.40	0.07
Quality Rating		0.10	2.13	0.07	1.54	0.11	0.78	0.00	0.82	0.00	0.77	0.00

*Significance at the .05 level. The .05 levels for F values with the following degrees of freedom are:
$F_{1,17}=4.45$ $F_{2,17}=3.59$ $F_{3,17}=3.20$ $F_{6,17}=2.70$ $F_{9,17}=2.49$

[a] ω^2 = proportion of total variance explained (omega squared). The missing cell in the Latin square design was estimated to compute the total sum of squares.

[b] CTBS=Comprehensive Tests of Basic Skills

If the dependent variable was adjusted before the data were analyzed, the name of the adjusting variable appears in the column labeled "Adjusting Variable." The majority of the adjusting variables are the pretreatment measures corresponding to the dependent variable, signified as "pre." Otherwise total reading score was generally used as the adjusting variable. The only exception to this rule was the Transfer Test. Since this measure had no corresponding pretreatment test, the pretreatment Essay subscale scores were used to adjust the parallel Transfer Test subscales. When no variable is listed in the column, no adjustment was made in the particular posttest score.

The column labeled "MS error" presents the error mean square from the analysis of variance of cell means or adjusted cell means and its degrees of freedom for each dependent variable.

The next five columns list the F-statistics computed for the main effect of treatment, of class within squares, of teachers within squares, of squares, and the treatment by square interaction, respectively. Also noted are the degrees of freedom associated with each effect. The critical values of the F-statistic at the 5 percent level of significance are presented in the footnote. F-statistics for dependent variables which are greater than the critical value are starred within the column to note statistical significance. The columns also show the omega squared (strength of association) statistics associated with each treatment effect. This statistic is interpreted as the percentage of variance in the dependent variable attributable to the treatment effect for that column. It should be noted that the total sum of squares term used in calculating values for Study I was found by summing the sums of squares for each effect. Thus, the estimated cell mean (see previous discussion of Latin square) is included in these calculations.

Main Effect of Treatment

Inspection of Table 16 shows that there were statistically significant differences at the 5 percent level between instructional treatment group means on seven achievement variables:

- Ecology Information Test Intentional Subscale I (post and delayed),
- Oral Test Content (post),
- Essay Test Logical Extension (post),
- Transfer Test Content (delayed),
- Written Question-Generating Test Non-Pertinent Questions (post),
- Written Question Generating Test Quality Rating (post), and
- Oral Question Generating Test Non-Pertinent Questions (post).

In a total of 18 independent significance tests made at the 5 percent level, about one significant result would be expected by chance. Therefore, it is likely that one of these significant differences occurred by chance. Cell means used in the analysis are reported in Appendix D.

It is interesting to note that treatment effects concentrated in the student outcome areas that represent more difficult levels of performance. Only one area of fact recall showed an effect and even this was in terms of retention of knowledge, a more difficult outcome than immediate recall of facts. The other measures to show effects were in higher cognitive performance and students' ability to generate questions such as those asked by the teacher during the discussions and/or in the written exercise.

Planned comparisons to determine which of the treatment means differed significantly from each other on these achievement variables are presented in the next section.

The percentage of variance attributable to treatment effect is reflected in the omega squared values. Especially noteworthy are the values for the Content subscale of the Oral Test and the Ecology Information Test Intentional

Subscale post and delayed. For the Content subscale the value was .30 suggesting treatment conditions had considerable influence on variance in students' performance on this measure. The omega squared values for the Ecology Information Test Intentional Subscale were .20 post and .19 delayed. This suggests that the measures were sensitive to the degree to which students acquired factual information as a result of various treatment conditions. In general, however, the effect of treatment on the types of achievement measures obtained in Study I was small in absolute value with the median of the omega-squared values equal to .08.

Planned Comparisons (Treatments).

Table 17 reports the results of the planned comparisons of the achievement measures. It lists each of the status and achievement test variables in the first column. The next four columns present cell means for each treatment in the Latin square design: probing and redirection, no probing and redirection, filler activity, and art activity, respectively. For those variables which were adjusted before entry into the analysis of variance, these values are adjusted cell means. The means for the art activity were calculated by including the estimated cell mean for the missing treatment group. A reference number (in parentheses) associated with each treatment is used in labeling the columns for planned comparisons.

The unadjusted cell means and 95 percent confidence limits for the written exercise treatment are presented in the next two columns. These results will be discussed later in this section.

The next three columns present F-statistics for the planned comparisons of treatment group means or adjusted means. The first of these columns compares probing and redirection with no probing and redirection (1 vs. 2);

TABLE 17

Study I
Treatment Means and Planned Comparisons of Measures of Ability, Achievement, and Attendance

DEPENDENT VARIABLE	ADJUSTING VARIABLE	TREATMENT MEANS						PLANNED COMPARISONS			
		Probe & Re-direct	No Probe & Red-direct	Filler Activ.	Art Activ. I	Writ. Exer.	95% Limits for Treat-ment 5	Treat-ments 1 vs 2	Treat-ments 2 vs 3	Treat-ments 1,2,3 vs 4	
		(1)	(2)	(3)	(4)	(5)		$F_{1,17}$	$F_{1,17}$	$F_{1,17}$	Prop.
STATUS VARIABLES											
Number of Sessions Attended		9.03	9.35	8.78	9.40[a]	9.23	8.84- 9.62	1.11	3.45	1.73	0.33[b]
CTBS[c] - Total Reading		58.89	54.42	53.81	50.16	57.45	14.65-100.25	1.96	0.04	3.89	0.56
KNOWLEDGE VARIABLES											
Ecology Information Test:											
Intentional Scale I, post	total rdng	5.79	6.00	6.16	4.73	6.20	5.61- 6.80	0.30	0.18	14.16*	0.94
Intentional Scale I, delay		5.69	5.13	5.73	3.89	5.15	4.37- 5.93	1.71	1.97	18.25*	0.88
Incidental Scale I, post		7.69	7.83	7.02	5.96	7.83	6.07- 9.59	0.04	1.56	7.41*	0.81
Incidental Scale I, delay	total rdng	7.00	6.89	6.40	5.93	7.08	5.36- 8.80	0.03	0.60	2.90	0.69
HIGHER COGNITIVE VARIABLES											
Oral Test:											
Content, post	pre	8.41	8.14	7.47	6.55	7.62	6.86- 8.38	0.40	2.54	15.24*	0.74
Logical Extension, post		2.59	3.33	2.92	2.09	2.79	1.75- 3.83	0.28	0.64	7.35*	0.80
Essay Test:											
Content, post	pre	10.72	10.58	9.86	9.09	9.79	8.45-11.13	0.06	1.62	6.72*	0.54
Logical Extension, post		1.79	1.58	1.40	0.91	1.46	1.26- 1.66	1.02	0.66	12.78*	0.79
Transfer Test:											
Content, delay	essay pre	8.15	8.09	6.85	6.93	6.80	5.60- 8.00	0.01	5.39*	2.67	0.26
Logical Extension, delay		1.56	1.55	1.39	0.97	1.42	1.24- 1.60	0.00	0.60	8.33*	0.93
QUESTION-GENERATING VARIABLES											
Written Question Generating Test:											
Non-pertinent Questions		0.52	0.52	0.41	0.95	0.56	0.48- 0.64	0.00	0.65	14.52*	0.93
Pertinent Questions	pre	12.41	10.97	11.94	11.38	13.33	-17.95-44.61	2.79	1.25	0.27	0.08
Specific Questions		3.30	2.96	3.05	2.12	3.87	-2.21- 9.95	0.79	0.05	8.54*	0.91
Request for Rationale		0.78	0.57	0.51	0.25	0.70	0.61- 0.79	1.79	0.16	7.50*	0.69
Quality Rating	pre	3.04	3.08	2.86	2.79	3.08	2.60- 3.56	0.19	4.43	4.76*	0.49
Oral Question Generating Test:											
Non-pertinent Questions		0.33	0.10	0.10	0.03	0.56	0.52- 0.60	5.55*	0.00	2.90	0.72
Pertinent Questions		1.36	1.82	1.64	1.43	1.65	1.41- 1.90	3.57	0.55	0.71	0.16
Quality Rating		0.80	1.00	0.96	1.14	0.95	0.88- 1.02	2.37	0.11	3.75	0.58

* Significance at the .05 level. The .05 levels for F values with the following degrees of freedom are:
$F_{1,17} = 4.45$ $F_{2,17}=3.59$ $F_{3,17}=3.20$ $F_{6,17}=2.70$ $F_{9,17}=2.49$

[a] Means for Art Activity Treatment I differ from the actual means because the missing cell value was estimated in the analysis of variance.

[b] Prop. = Sum of squares for Treatments 1,2,3 vs. 4 as a proportion of total treatment sum of squares.

[c] CTBS = Comprehensive Tests of Basic Skills

the second contrasts no probing and redirection with filler activity (2 vs. 3). The next column compares the average effect of the three recitation treatments with the non-recitation art activity treatment. Each of these planned comparisons has one degree of freedom and was tested using the error mean square from the analysis of variance. The critical value of the F-statistic for 1 and 17 degrees of freedom at the 5 percent level of significance is provided. F-statistics which are statistically significant at the 5 percent level are starred. In the column labeled "Prop," the ratio of sum of squares for the contrast to sum of squares for the main effect of treatments is presented. This is a measure of the proportion of variability among the four treatments accounted for by the difference between the mean of the discussion treatments and the non-discussion treatment. In other words, this ratio indexes the degree to which discussion was the contributing factor in the main effect for treatments.

The planned comparisons of treatment differences indicate that there was little difference in the effects of the discussion treatments of probing and redirection, no probing and redirection, and filler activity on achievement test variables. Exceptions to this generalization are that the probing and redirection treatment groups generated significantly more oral non-pertinent questions than the no probing and redirection groups; and the no probing and redirection groups achieved a reliably greater transfer test content score than did the filler activity. Because of the substantial number of comparisons involved in this analysis, it is quite possible that these two significant differences are a chance finding.

These results relate to one of the research objectives of Study I: to determine what student learning objectives are affected by presence or absence of probing and redirection in discussion. The results indicate that teacher use of probing and redirection techniques in discussion does not facilitate knowledge acquisition, higher cognitive response ability, or question-generating ability. Possible explanations of this lack of effect of the skills within the discussion treatments will be presented in Chapter Seven. They will be considered in view of the findings of Study II as well as the results reported here.

It is important to note that these findings also suggest that time in discussion may be of limited importance. Inasmuch as the filler activity treatment controlled for time in discussion without use of probing and redirection, the failure to identify significant differences between the no probing and redirection treatment and the filler and the probing and redirection treatments indicates approximately ten minutes of additional time provided by these latter two treatments had limited effect.

On the other hand, the comparison of the average of the three recitation treatments versus art activity reveals that discussion in and of itself promotes statistically significant improvements ($p<.05$) in achievement on the following measures:

- Ecology Information Test Intentional Subscale I (post and delayed),
- Ecology Information Test Incidental Subscale I (post),
- Oral Test Content (post) and Logical Extension (post),
- Essay Test Content (post) and Logical Extension (post),
- Transfer Test Logical Extension (post),
- Written Question-Generating Test, Non-pertinent Question (post),
- Written Question-Generating Test, Specific Questions,
- Written Question-Generating Test, Request for Rationale, and
- Written Question-Generating Test, Quality Rating.

The proportion of total between treatment variability accounted for by the comparison of discussion treatments with the art activity was substantial, ranging from .08 to .94 with 12 of the 18 comparisons having a ratio greater than or equal to .65.

These results relate to the research objective of Study I concerning which student learning objectives are affected by presence or absence of discussions. They indicate that discussion of the type incorporated in the three discussion treatments is more effective than a competing no discussion treatment in facilitating knowledge acquisition, ability to respond to higher cognitive questions both orally and in written form, and ability to generate questions.

It therefore appears that the overall strategy of discussion is an important means for building both students' fact recall and higher cognitive skills. Because the discussions included in Study I were carefully planned and presented, based on the semi-programmed format given to the teachers, it is difficult to determine whether this strong effect should be attributed to discussion per se. However, it seems necessary to assume that the findings should be limited to only those teacher-directed discussions that are planned and structured similarly to those used in the study.

The unadjusted cell means for the written exercise treatment are presented in column 8 of Table 17. The next column, labeled "95% Limits for Treatment 5," presents a "confidence" interval about each written exercise treatment mean. The mean square error term from the analysis of variance was used in calculating these limits. To the extent that the written exercise treatment is comparable to the other treatment means, this term is the best estimate of between-group variability. The formula for this confidence band is:

$$\bar{Y} = (2.11)\ \frac{\text{MS error}}{\sqrt{n}} \leq \mu y \leq \bar{Y} + (2.11)\ \frac{\text{MS error}}{\sqrt{n}},$$

where: $\bar{Y}$ = written exercise treatment mean,

MS error = mean square error term from column 3, and

n = number of cell means used in calculating $\bar{Y}$

To the extent that other treatment means lie within this confidence band, the written exercise treatment probably can be judged approximately as effective as those other treatments.*

Applying this procedure to the achievement measures, the written exercise treatment appears to promote more learning relative to the art activity treatment on a variety of post dependent variables:

- the Intentional Scale (post and delayed) and Incidental Scale (post) of the Information Test
- the Content Scale of the Oral Test (post)
- the Logical Extension Scale of the Essay (post) and Transfer Tests (delayed) and
- the Request for Rationale Scale (post) of the Written Question-Generating Test.

In contrast, the art activity treatment exceeded the 95 percent limit on a single scale: the quality rating scale (post) of the Oral Question-Generating Test.

Several differences between the written exercise treatment and the probing and redirection treatment can be identified. The probing and redirection means for the higher cognitive response variables fell slightly above the 95 percent limits on the Content Scale (post) of the Oral Test, the Content Scale (delayed) of the Transfer Test, and the Logical Extension Scale (post) of the Essay Test. The probing and redirection means fell below the 95 percent limits on quality and frequency of pertinent questions on the Oral Question-Generating Test (post).

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* For those analyses in which the dependent variable was residualized, the limits were calculated about an unresidualized written exercise treatment mean using the residualized mean square error. Thus, the "tests" for reliable differences between the written exercise treatment and other treatment means probably are liberal.

A few treatment means for the other discussion treatments also fell above or below the 95 percent limits of the corresponding written exercise treatment means, but they do not define a meaningful pattern.

These findings relate to the third objective of Study I, which was to determine the relative effect on student learning of teachers' questions delivered in discussions compared with the same questions presented and answered in written format. It appears that questions in written format are generally as effective as questions in discussions in promoting knowledge acquisition and question-generating ability. However, written questions are not as effective as discussion questions which are probed and redirected in promoting higher cognitive response ability. Finally, questions in written format appear to be more effective than a competing instructional method (art activity) in promoting some learning outcomes related to knowledge acquisition, higher cognitive response ability, and question-generating ability.

Classroom, Teacher, and Square Effects

Classroom Effects. The analysis of variance confirmed prior expectations in revealing significant differences among classrooms on the majority of achievement measures. These included: Ecology Information Test Intentional Subscale I (post and delayed), Essay Test Content (post) and Logical Extension scales (post), Transfer Test Content (delayed) and Logical Extension scales (delayed), and all five of the measures derived from the Written Question-

Generating Test. The omega squared values were generally large for the effect of classroom, ranging from .00 to .43 with a median of .22. It is interesting to note that the oral measures of achievement showed no significant classroom effects and generally had the lowest omega squared values. Since these variables were most directly related to the conditions of the discussion treatments rather general classroom conditions, this finding lends credence to the use of such measures in the study and suggests that they may be the most important estimates of treatment effect.

Teacher Effects. In only one case, the Request for Rationale Scale of the Written Question-Generating Test, was there a significant main effect found for ecology teachers. The omega squared values range from .00 to .13, with a median of .01. Thus, it may be assumed that differences in achievement measures are not attributable to variation among the ecology teachers. Given the findings reported in the fidelity of treatment section, this lack of teacher effect is particularly important. Although one ecology teacher failed to maintain the desired time limits, this and other non-reported differences among teachers did not affect treatment outcomes.

The implications of this finding, particularly as it relates to the use of the semi-programmed approach to discussion, will be discussed in Chapter Seven. For the most part questions are raised relative to whether use of such an approach reduces the impact of other teacher characteristics such that the effects of the particular teaching strategies to be studied, in this instance probing and redirection, will become more pronounced or whether it controls so many aspects of the learning situation that the effects are, in fact, masked and/or of secondary importance.

Square Effects. The analysis of variance for squares showed statistically significant differences only in the case of the two transfer test measures and the measures obtained from the Written Question-Generating Test. The omega squared values for the square effect over all the dependent achievement variables ranged from .00 to .31 with a median of .02.

While square effects were minimal, the square effect for total reading score approached statistical significance (see Table 16). Based upon this finding, the hypothesis was formulated that the square effects that were identified for dependent variables could reflect pre-existing differences in reading ability. This hypothesis was tested first by computing the mean of the total reading scores for the set of treatment groups within each Study I Latin square. The result of this analysis is shown in Table 18. It is apparent that the total reading score mean for Square 1 is substantially higher than the other two square means, which are quite similar in magnitude. If the significant square effects observed in Table 16 reflect these pre-existing differences in reading score, the mean for Square 1 should be greater than the other two square means for each dependent variable for which a significant square effect was identified. Table 18 includes the square means for the transfer test and written question-generating test variables. In each instance, Square 1 has the highest mean. Further, the difference between the Square 1 mean and the other two square means generally is greater than the difference between the means of Square 2 and Square 3. Thus, a plausible explanation of the observed square effect is that by chance the classes assigned to Square 1 were of higher initial ability than the classes assigned to the other two squares.

TABLE 18

Study I

Latin Square Means for Variables Exhibiting Square Effect

VARIABLE	SQUARE 1 $\overline{X}$	SQUARE 2 $\overline{X}$	SQUARE 3 $\overline{X}$
Comprehensive Test of Basic Skills, Total Reading Score	58.62	52.72	52.19
Transfer Test, Content Scale	8.82	6.36	7.22
Transfer Test, Logical Extension	1.75	0.91	1.45
Written Question-Generating Test, Non-Pertinent Questions	.73	.30	.52
Written Question-Generating Test, Pertinent Questions	13.57	10.08	11.20
Written Question-Generating Test, Specific Questions	3.28	2.49	2.84
Written Question-Generating Test, Requests for Rationale	1.04	.15	.55
Written Question-Generating Test Quality Rating	2.92	2.64	2.53
Ecology Unit Opinions, Attitude toward Ecology Curriculum	31.76	29.43	29.61

While this finding is of some concern, the inclusion of all discussion treatments in each square and the adjustment of post and/or delayed measures for entering ability lessens the extent to which the proposed square effects must be considered in interpreting treatment outcomes.

Square by Treatment Interactions. There were three dependent variables for which there was a statistically significant effect of square by treatment interaction, namely, the Written Question-Generating Test measures of Specificity, Request for Rationale, and Quality Rating.

ATTITUDE MEASURES

Table 19 presents the results of the analysis of variance for scales derived from the following attitude measures: Word Association Scale, Gall-Crown Discussion Attitude Scale, Ecology Unit Opinions Scale, and Ecology Discussion Attitude Scale.* The Written Exercise Attitude Scale and Ecology Art Project Scale were not included in this analysis since these scales were administered only to students in the treatment for which they were designed (written exercise treatment and art activity I treatment, respectively).

Table 19 is organized according to the same format as Table 16. The leftmost column lists the names of the dependent variables. Whenever the dependent variable was adjusted before the data were analyzed, the name of the adjusting variable appears in the column labeled "Adjusting Variable." The column labeled "MS error" presents the error mean square from the analysis of variance for all means or all adjusted means. The

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* Analysis of variance for the two subscales derived from the Ecology Discussion Attitude Scale included only the three discussion treatments. This measure was not administered to students in the Art Activity and Written Exercise treatments since they did not participate in ecology discussions.

TABLE 19

Study I

Analysis of Variance of Attitude Scale Scores

DEPENDENT VARIABLE	ADJUSTING VARIABLE	MS error df=17	F VALUES AND ω^2 FOR ANALYSIS OF VARIANCE EFFECTS									
			Treatment		Class		Teacher		Square		Treatment by Square	
			$F_{3,17}$	ω^2	$F_{9,17}$	ω^2	$F_{9,17}$	ω^2	$F_{2,17}$	ω^2	$F_{6,17}$	ω^2
CURRICULUM-RELATED VARIABLES												
Word Association Scale:												
Balance of Nature		17.67	0.92	0.00[a]	2.11	0.17	2.33	0.20	1.93	0.03	1.90	0.09
Ecology		21.16	1.15	0.01	2.12	0.25	1.47	0.11	0.11	0.00	0.48	0.00
Wolf	pre	32.55	1.30	0.02	0.92	0.00	0.87	0.00	0.10	0.00	1.07	0.00
Air Pollution		10.59	1.14	0.00	1.44	0.09	0.45	0.00	0.14	0.00	0.93	0.00
Alligator	pre	27.90	2.24	0.07	1.20	0.03	0.88	0.00	0.28	0.00	1.42	0.04
Water Pollution	pre	9.58	1.14	0.00	0.88	0.00	0.59	0.00	0.15	0.00	1.06	0.00
DISCUSSION VARIABLES												
Gall-Crown Discus. Attitude Scale:												
Att. toward Thought Ques.	pre	7.96	0.25	0.00	1.71	0.15	0.55	0.00	0.52	0.00	0.37	0.00
Attitude toward Discussion	pre	8.39	1.32	0.01	5.38*	0.33	2.44	0.13	0.56	0.00	1.16	0.01
GENERAL TREATMENT VARIABLES												
Ecology Unit Opinions Scale:												
Attitude toward Peers		3.46	0.16	0.00	1.56	0.08	2.43	0.20	0.50	0.00	1.05	0.00
Attitude toward Teacher		10.74	1.53	0.02	3.80*	0.32	1.97	0.11	0.91	0.00	0.36	0.00
Attitude toward Curriculum		4.32	1.64	0.02	4.06*	0.29	1.87	0.08	6.18*	0.11	0.81	0.00
TREATMENT-SPECIFIC VARIABLES												
Ecology Discussion Attitude Scale:												
Att. toward Thought Ques.		3.83	2.10	0.01	4.10*	0.31	2.67*	0.16	1.41	0.00	0.74	0.00
Attitude toward Discussion	GDAS-Disc pre	4.54	3.64*	0.03	3.08*	0.16	6.12*	0.41	0.71	0.00	0.40	0.00

* Significance at the .05 level. The .05 levels for F values with the following degrees of freedom are:
$F_{1,17}=4.45$ $F_{2,17}=3.59$ $F_{3,17}=3.20$ $F_{6,17}=2.70$ $F_{9,17}=2.49$

[a] ω^2 = proportion of total variance explained (omega squared). The missing cell in the Latin square design was estimated to compute the total sum of squares.

next five columns list the F-statistics and strength of association statistics (omega squared) for the main effect of treatment, of class within squares, of teachers within squares, of squares, and the treatment by square interaction respectively. Cell means on which the analysis was based for each variable are reported in Appendix D.

Main Effect of Treatment

Table 19 indicates that overall the treatment effect was statistically significant only for the Attitude toward Discussion subscale of the Ecology Discussion Attitude Scale ($p<.05$). Omega squared values were consistently small with only one exceeding .05. Further, perusal of cell means for the various attitude measures (see Appendix D, Tables D-20 through D-34) indicates that students generally were highly positive about the various treatment conditions. This, in turn, raises questions regarding the possible occurrence of a Hawthorne effect which may have been maintained over the nine day treatment period.

Planned Comparisons

Planned comparisons involving the differential effects of treatments on attitude scales are presented in Table 20. This table is organized according to the same format as Table 17, which presents the planned comparisons involving the achievement variables of Study I. To restate the format, the attitude scales are listed in the first column; the next four columns present adjusted or unadjusted cell means for the discussion treatments and the art activity; the unadjusted cell means and 95 percent confidence limits for the written exercise treatment are presented in the next two columns; the next three columns present

Table 20

Study I

Treatment Means and Planned Comparisons of Attitude Measures

DEPENDENT VARIABLE	ADJUSTING VARIABLE	TREATMENT MEANS						PLANNED COMPARISONS			
		Probe & Redirect (1)	No Prb & Redirect (2)	Filler Activ. (3)	Art Activ. I (4)	Writ. Exer. (5)	95% Limits for Treatment 5	Treatments 1 vs 2 $F_{1,17}$	Treatments 2 vs 3 $F_{1,17}$	Treatments 1,2,3 vs 4 $F_{1,17}$	Prop.
CURRICULUM-RELATED VARIABLES											
Word Association Scale:											
Balance of Nature		55.62	57.61	57.66	55.52[b]	54.35	39.54-69.16	1.35	0.00	0.91	0.33[b]
Ecology		58.41	61.38	61.13	61.34	60.48	48.11-72.85	2.50	0.02	0.40	0.11
Wolf	pre	47.27	47.66	45.48	43.30	50.87	28.09-73.66	0.03	0.88	0.91	0.74
Air Pollution		60.29	59.35	58.29	58.05	58.23	50.82-65.64	0.50	0.64	1.14	0.91
Alligator	pre	52.55	51.62	51.96	47.18	48.49	28.96-68.02	0.19	0.02	6.54*	0.97
Water Pollution	pre	59.58	59.39	57.95	57.63	59.18	52.47-65.89	0.02	1.29	1.44	0.42
DISCUSSION VARIABLES											
Gall-Crown Discus. Attitude Scale:											
Att. toward Thought Ques.	pre	30.29	31.14	30.31	30.36	28.60	23.03-34.17	0.54	0.51	0.05	0.06
Attitude toward Discussion	pre	54.86	56.45	54.97	54.06	53.69	47.82-59.56	1.80	1.57	1.71	0.43
GENERAL TREATMENT VARIABLES											
Ecology Unit Opinions Scale:											
Attitude toward Peers		15.38	16.14	16.41	16.19	16.00	13.57-18.43	0.12	0.13	0.01	0.01
Attitude toward Teacher		55.88	57.57	56.63	54.65	58.37	50.81-65.93	1.60	0.49	2.99	0.65
Attitude toward Curriculum		29.97	31.36	31.18	29.50	30.86	27.82-33.90	2.68	1.93	1.80	0.37
TREATMENT-SPECIFIC VARIABLES											
Ecology Discussion Attitude Scale:											
Att. toward Thought Ques.		31.56	33.20	32.27				4.18	3.42		
Attitude toward Disc.	GDAS-Disc. pre	57.76	59.88	57.94				5.92*	7.23*		
Written Exercise Attitude Scale:											
Att. toward Thought Questions						31.68					
Attitude toward Writt. Exer.						35.82					
Ecology Art Project Scale:											
Attitude toward Art Projects					61.85						

* Significance at the .05 level. The .05 levels for F values with the following degrees of freedom are:
$F_{1,17}=4.45$ $F_{2,17}=3.59$ $F_{3,17}=3.20$ $F_{6,17}=2.70$ $F_{9,17}=2.49$

[a] Means for Art Activity Treatment I differ from the actual means because the missing cell value was estimated in the analysis of variance.

[b] Prop. = Sum of squares for Treatments 1, 2, 3 vs. 4 as a proportion of total treatment sum of squares.

F-statistics for the planned comparisons; and the final column, labeled "Prop," is the proportion of variability among the four treatments accounted for by the differences between the mean of the discussion treatments and the non-discussion treatment.

Planned comparisons of the discussion treatments (probing and redirection versus no probing and redirection, no probing and redirection versus filler activity) revealed only a single difference which was statistically significant. The no probing and redirection treatment mean was statistically greater than both the probing and redirection treatment mean and the filler activity treatment mean on the Attitude toward Discussion Subscale of the Ecology Discussion Attitude Scale. This was the same subscale which showed a significant difference in the analysis of variance for the main effect of treatment. However, because of the substantial number of statistical tests which were performed, it is quite probable that these findings are chance results.

One research objective of Study I was to determine what student learning outcomes were affected by presence or absence of probing and redirection in discussion. The results indicate that presence of probing and redirection techniques in discussion does not promote more positive student attitudes toward curriculum-related topics or discussions in general than discussions where these are absent; also, use of such techniques is not perceived any more favorably than their absence. It should be noted, however, that on the whole students were highly positive about all discussion situations.

The planned comparison of the average of the three discussion treatments versus the art activity treatment revealed one significant difference--

students' scores on the Alligator Subscale of the Word Association Scale. The proportion of total between-treatment variability in the attitude measure scores accounted for by planned comparisons of discussion versus art activity was generally lower than was found for the achievement measures.

Since the treatment-specific attitude scales incorporated different items and were of different lengths, their mean scores cannot be compared directly. However, a rough comparison can be made by computing the students' average rating per item,* since each scale used the same four-point rating scheme: strongly agree, agree, disagree, strongly disagree. For the single significant difference in treatment means, the average rating per item on the Attitude Toward Thought Questions Subscale was 2.94 for students in the discussion treatments and 2.88 for students in the written exercise treatments. The mean on the Attitude toward Discussion Subscale was 3.08 for the students in all discussion treatments. The art activity students had an average rating of 3.26 on the comparable scale (Ecology Art Project Scale) and the students in the written exercise treatment had a mean score of 2.99 on the comparable scale (Attitude Toward Written Exercises).

These results relate to another research objective of Study I, which is to determine what student learning outcomes are affected by presence or absence of discussions. The results indicate that discussion treatments are equally as effective as a competing no-discussion treatment in promoting positive student attitudes toward curriculum-related topics and toward discussions in general; both types of treatment are perceived favorably.

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* The rating is obtained by dividing the total score by the number of items in the scale.

The unadjusted cell means of the attitude scales for the written exercise treatment are presented in column 7 of Table 20. The column labeled "95% limits for Treatment 5" presents a confidence interval about each written exercise treatment mean. To the extent that other treatment means lie within this confidence band, the written exercise treatment probably can be judged approximately as effective as those other treatments.*

Applying this procedure to the attitude scales, it appears that none of the discussion treatment means or art activity means on the attitude scales fell outside of the 95 percent limits for the corresponding written exercise treatment means. This finding is surprising given that the ecology teachers reported considerable difficulty maintaining student interest in the written exercise activities.

As noted earlier, the scores of the written exercise treatment group on their treatment-specific scale (Written Exercise Attitude Scale) cannot be compared directly to the scores of the other treatment groups on their respective treatment-specific scales (Ecology Discussion Attitude Scale and Ecology Art Project Scale). However, as on page 96, a rough comparison can be made by computing the students' average rating per item. The average rating per item for each scale is presented in Table 21. Students in the written exercise treatment generally gave positive ratings on a four-point scale to their learning experiences. Their ratings were only slightly less positive than ratings of students in the combined discussion treatments and moderately less positive than ratings of students in the art activity treatment.

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* Additional information about computation of the confidence limits is presented on page 83.

TABLE 21

Study I

Average Ratings Per Item of Treatment-Specific Attitude Scales

TREATMENT GROUP	SCALE	AVERAGE RATING PER ITEM
Combined Discussion Treatments	Ecology Discussion Attitude Scale	
	Attitude Toward Thought Questions	2.94
	Attitude Toward Discussion	3.08
Art Activity Treatment	Ecology Art Project Scale	3.26
Written Exercise Treatment	Written Exercise Attitude Scale	
	Attitude Toward Thought Questions	2.88
	Attitude Toward Written Exercises	2.99

These results relate to the third objective of Study I concerning the relative effects on student learning of teachers' discussion questions compared with the same questions in written format. It appears that questions in written format generally are as effective as questions in discussions in promoting positive attitudes toward curriculum-related topics and toward discussions in general; and they are perceived with approximately equal favorability as a learning experience.

Classroom, Teacher, and Square Effects

Classroom Effects. As reported in Table 1[illegible], there were statistically significant differences between classrooms for most of the scales measuring attitudes toward teachers and teaching methods. The omega squared values were generally large for these measures, ranging from .08 to .33, with a median of .29. No significant effects were found for attitudes toward ecology. While the similarity of the various Study I treatments to the students' regular classroom experiences was not investigated, the presence of the classroom effect suggests that the regular learning environment of the students may have had a significant effect upon the outcomes. The importance to the study of the Latin square design in which all treatments were included in each class is underlined by this finding.

Teacher Effects. The main effect for ecology teachers was statistically significant for the two subscales of the Ecology Discussion Attitude Scale and approached significance for two others--the Attitude toward Discussion subscale of the Gall-Crown Discussion Attitude Scale and the Attitude toward Peers subscale of the Ecology Unit Opinions Scale. The omega squared values ranged from .00 to .41, with a median of .11. Non-controlled differences in teachers appear to have had more impact on attitudinal outcomes than on achievement outcomes.

Square Effects. The main effect for squares was statistically significant for only one subscale (the Attitude toward Curriculum subscale of the Ecology Unit Opinions Scale), and can be attributed to chance.

Square by Treatment Interactions. None of the square by treatment interactions were significant.

STATUS VARIABLES

Treatment Main Effects

To assure that the results for various post and delayed measures were not simply reflecting pre-existing differences among the students assigned to the various treatments, analyses of variance were performed on the total reading scores; that is, the sum of Vocabulary and Comprehension Subscale scores from the Comprehensive Tests of Basic Skills, and on average number of treatment lessons attended by students within a group. Table 16 (see page 78) presents the results of this analysis. No effects significant at the 5 percent level were observed, and omega squared values were generally small, ranging from .01 to .13 across the analysis of variance effects.

Planned Comparisons. The status variables of verbal ability and session attendance were analyzed in three planned comparisons involving the following treatment means: probing and redirection versus no probing and redirection, no probing and redirection versus filler activity, and the combined discussion treatments mean versus art activity. These results are presented in Table 17 (page 82).

None of the planned comparisons was statistically significant at the .05 level. However, the comparison of the combined discussion treatments mean and the art activity mean on the verbal ability measure approached statistical significance. The probing and redirection treatment mean is greater than the two treatments in which probing and redirection were absent; and their combined mean is greater than the art activity treatment mean. It therefore seems reasonable to conclude that differential absenteeism among treatment groups is unlikely to have been influential in producing treatment differences on achievement test and attitude scale results. However, there is a possibility that at least some of the observed treatment differences on achievement tests and attitude scales may have been the result of differential verbal ability.

SUMMARY

The results of Study I can be summarized by referring to the three research objectives which guided this study.

1. The first research objective was to determine what learning outcomes were affected by presence or absence of probing and redirection techniques in discussion. The results of the data analyses in Study I indicate that probing and redirection did not facilitate students' acquisitioin of knowledge, higher cognitive response ability, or question-generating ability more than use of discussions in general; nor did these techniques promote more positive student attitudes toward curriculum-related topics or toward discussions than did discussions in general. Also, use of such techniques during discussions was not perceived any more favorably than their absence.

2. The second research objective was to determine what student learning outcomes were affected by presence or absence of discussions. The results of the data analyses in Study I indicate that discussions were more effective than a competing instructional method (art activity) in facilitating students' acquisition of knowledge, higher cognitive response ability, and question-generating ability. Both instructional methods were perceived positively by students.

3. The third research objective was to determine the relative effect on student learning of teachers' questions delivered in discussion compared with the same questions presented and answered in written format.

The results of the data analyses in Study I indicate that questions in written exercises were as effective as questions in discussions in facilitating knowledge acquisition and question-generating ability; and they were also as effective as discussion questions in promoting positive attitudes toward curriculum-related topics and toward discussions in general. However, written questions were not as effective as discussions in which questions were probed and redirected in facilitating higher cognitive response ability.

As a tentative generalization, it might be said that it is important for teachers to conduct discussions to supplement students' reading/viewing of curriculum material. However, inclusion of specific discussion techniques (i.e., probing and redirection) does not appear to be as important as whether the discussions are conducted. Further, written exercises apparently can be substituted for discussions to promote learning, except when the teacher is seeking to stimulate students' ability to give higher cognitive responses. For this type of learning objective, discussion by probing and redirection is the preferred method.

Analysis of other effects in the Latin square design--teacher, class, square, and treatment by square did not reveal striking or unexpected findings. Perhaps most noteworthy is the absence of a significant teacher effect in the analysis of variance, indicating that differential teacher characteristics did not influence implementation of the various treatments.

The analysis of reading ability scores revealed some pre-existing differences among treatment groups which may have accentuated observed treatment effects. However, since these differences were not statistically significant, they do not present a significant competing hypothesis for interpreting findings.

SECTION III

STUDY II

The Effects of Teacher Use of Higher Cognitive Questions on Student Achievement and Attitudes

The report of Study II, The Effects of Teacher Use of Higher Cognitive Questions on Student Achievement and Attitude, is organized into the same three major chapters as the report of Study I: first, the methodology of the experiment is described; second, the results of the experiment are presented; finally, there is a discussion of the results of both Study I and Study II. Technical issues are discussed in the appendices.

CHAPTER FIVE

METHODOLOGY OF STUDY II

The discussion of methodology covers six main topics: treatments, curriculum, participants including both teachers and pupils, instrumentation, research design, and analysis.

TREATMENTS

As with Study I, the discussion of treatments includes two subtopics. The first is a description of the treatments and the procedures related to their implementation. The second is a discussion of the fidelity of treatment in Study II. Fidelity of treatment provides information on the disparity between the intended treatment and the actual treatment as implemented by the participants. The more closely the actual treatment corresponds to the intended treatment, the greater the treatment fidelity is said to be. Fidelity of treatment is an important aspect of this kind of experiment because results can be contaminated by uneven or idiosyncratic implementation of the intended treatment.

Description of Treatments

Study II included four treatment conditions--three discussion treatments and an art activity treatment. The treatments were administered to students randomly formed into treatment groups from sixth-grade classrooms in a single school district. All of the treatments used a specially prepared curriculum on ecology. The curriculum is fully described on pages 29 to 37 of this volume. The treatments were administered by specially-trained teachers (referred to in this report as ecology teachers), not by the students' regular teachers. Each ecology teacher taught four different treatment groups each day. A discussion follows of each of the treatment conditions.

Discussion Treatments. As noted above, the three discussion treatments in Study II all used the ecology curriculum. As in Study I, this curriculum consisted of one warm-up lesson and nine regular lessons, one lesson a day was conducted during a fifty-minute session. Presentation of curriculum materials typically required 15 to 20 minutes. The next 20 to 30 minutes were used for the various types of discussions. Each discussion, irrespective of treatment condition, consisted of 16 questions. The decision to use 16 questions was based upon pilot work which indicated that teachers in the sixth grade typically can ask 15 to 20 substantive questions in a 20 to 30 minute period without a time difficulty for either the teacher or the students.

Depending upon the discussion treatment, the 16 questions were variously divided among fact, multi-fact, and higher cognitive questions. The fact and multi-fact questions corresponded to Bloom's knowledge levels. The higher cognitive questions were based on the processes included in the upper levels of Bloom's cognitive taxonomy.

The criteria used to generate the fact and multi-fact questions were the same as those applied in Study I (See pp. 18 to 19 for discussion of procedures used to generate the questions).

The three discussion treatments* that were developed to test effects of higher cognitive questions were as follows:

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* The discussion treatments were pilot tested as part of the initial try-out of the ecology curriculum. See pages 35 to 37 for a description of the pilot test.

25% Higher Cognitive Question (HCQ) Treatment. This treatment consisted of nine discussions each of which contained eight fact questions, four multi-fact questions, and four higher cognitive questions. The discussion questions which comprised the nine lessons are presented in Volume II. The ecology teachers were trained to ask these questions exactly as given to them. In addition, they were instructed to probe and redirect the multi-fact and higher cognitive questions, as appropriate. In effect, this treatment was equivalent to the probing and redirection treatment in Study I except for the different proportion of higher cognitive questions. These discussions were approximately 17 minutes in length. An additional 12 minutes of filler activity was assigned for each lesson in order to equate length to that of the 75 percent treatment. The filler activities in this treatment and in the 50% HCQ treatment were drawn from the filler activity treatment in Study I; see page for a description of the filler activities.

50% Higher Cognitive Question (HCQ) Treatment. This treatment was identical to the probing and redirection treatment in Study I. The discussions contained the same four multi-fact and same four higher cognitive questions as in the 25% HCQ treatment. However, four additional higher cognitive questions (not in the 25% HCQ treatment) were included while only four of the fact questions contained in the 25% HCQ treatment were used. These discussions lasted approximately 23 minutes. An additional six minutes of filler activity was assigned to each lesson in order to equate time with the 75 percent treatment. The questions for this treatment also are presented in Volume II.

75% Higher Cognitive Question (HCQ) Treatment. This treatment consisted of nine discussions each of which included four multi-fact questions and twelve higher cognitive questions (see Volume II for listing of questions). The four multi-fact questions were the same as those in the preceding two treatments. Of the twelve higher cognitive questions, four were unique to this treatment; four appeared in both this treatment and the 50% HCQ treatment; and four were common to all the discussion treatments. The 75 percent HCQ discussions were expected to require approximately 29 minutes to complete.

The "semi-programmed discussion" technique used in Study I also was applied here. In this technique, the teacher follows a script which prescribes the questions to be asked and in what sequence. The script is only "semi" programmed because some teacher behaviors are contingent upon student responses. For example, in Study II teacher probing and redirection of multi-fact and higher cognitive questions was contingent upon the student's response. If a student was unable to express a response to the initial question (e.g., an "I don't know" response), the teacher could not probe to elicit a rationale or elaboration of the answer. Thus, the script could dictate the question to be asked and approximately how many times probing was to occur but it could not prescribe which student responses would be probed.

To insure that students in all discussion treatments were exposed to the same amount of correct information, a set of exemplary responses was provided for each question. Whenever no student gave an acceptable answer to a question, the teacher provided one from this set.

The reason for using the semi-programmed discussion format was to control, as much as possible, the content and form of the treatment received by the students.

Art Activity Treatment. This treatment was the same as the art activity in Study I except each treatment group in Study II contained more students.

The students in this treatment viewed and/or read the same ecology curriculum materials as the students in the discussion treatments. Instead of discussion, though, they participated in nine sessions of ecology-related art activities. During these sessions, the ecology teachers were instructed to ask none of the questions incorporated in the various discussion treatments. The time allotted for each [illegible] activity lesson was approximately equal to that of the 75 percent HCQ treatment, 29 minutes.

The sequencing and types of art activities were allowed to vary at the discretion of the ecology teachers. Each teacher was given a packet of art activity suggestions. A particular activity could last for one period or could be continued over successive days. A description of some of the activities is included in the Study I report (see page 21).

Summary of Treatments. Table 22 summarizes the similarities and differences among the four treatment conditions used in Study II.

TABLE 22

Study II Treatments

Treatment	Content
25% Higher Cognitive Questions	Curriculum materials followed by discussion including 8F + 4MF + 4HCQ + probing and redirection.
50% Higher Cognitive Questions	Curriculum materials followed by discussion including 4F + 4MF + 8HCQ + probing and redirection.
75% Higher Cognitive Questions	Curriculum materials followed by discussion including 4MF + 12HCQ + probing and redirection.
Art Activity	Curriculum materials followed by ecology-related art activity.

F = Fact question
MF = Multi-fact question
HCQ = Higher cognitive question

Fidelity of Treatment

Fidelity of treatment was verified along two dimensions. First, a check was made on how well teachers implemented the treatment as defined in the semi-programmed instructions. Second, the time required for treatment implementation was checked. The results of both of these checks follow.

Adherence to treatment conditions. Since the discussion treatments were semi-programmed, adherence to the conditions of question sequence and use of probing and redirection were essential for maintenance of treatment. In the art activity treatment, it was essential that the teachers conducted no discussions.

As in Study I, the extent to which the ecology teachers in Study II maintained the various discussion treatment conditions was checked by audiotaping three of the discussions conducted by each teacher on each of two days (Lesson 2 and Lesson 7). This sample of six discussions per teacher was rated to establish treatment fidelity. A total of 72 discussions were rated for Study II. These were contained on a set of 52 audiotapes which included discussions from both Studies I and II. Thirty of the tapes were scored by two raters. Twenty-two tapes were scored by only one rater due to cost considerations. Since the tapes were assigned for scoring on a random basis, there is no reason to believe that the ratings of the single-scored tapes differed systematically from the double-scored tapes.

The audiotapes first were scored to determine whether the ecology teacher:

- asked (or omitted) each of the 16 scripted quesions;
- made substantial changes in the wording of a question;
- asked the questions in a different order than they were listed in the script.

Based upon this analysis, the teachers appeared to have followed the question format. Deviations from the scripts were so infrequent that a statistical summary was not necessary. In only six of the 144 discussions which were audiotaped in Study I and Study II (72 in each study), did teachers vary the order of the questions. Other deviations either did not occur or occurred very infrequently.

The audiotapes also were rated for frequency of several teacher behaviors which reflected implementation of the treatment conditions. These behaviors included probing, redirection, praise, giving feedback about the accuracy of a student's answer, and giving all or part of an answer to the question (rather than the students giving the answer). Interrater agreement on the frequency of occurrence of these behaviors was checked for those audiotapes scored by both raters. The intraclass correlation coefficients for the double ratings were .93 for probing, .90 for redirection, .91 for praise, .65 for feedback, and .91 for giving answers.

Table 23 presents the results of teacher use of the behaviors in Study II. Generally, the ecology teachers' performance reflected the instructions given in their training for Study II. They were asked to probe and redirect each multi-fact and higher cognitive question, while staying within certain time limits. Since the 25%, 50%, and 75% higher cognitive question treatments contained progressively more of these types of questions, a progression in use of probing and redirection would be expected. This was in fact the case both in Lesson 2 and in Lesson 7. The same progression occurred, although not as clearly, in the other three behaviors: praise, feedback, and gives answer. The greatest difference occurred between the 25% HCQ treatment and the other two treatments, which differed negligibly

TABLE 23

Study II

Teacher Behavior Patterns in Discussion Treatments

Teacher Behavior	25% HCQ* N= 12 Teachers		50% HCQ N= 12 Teachers		75% HCQ N= 12 Teachers	
	$\overline{X}$	S.D.	$\overline{X}$	S.D.	$\overline{X}$	S.D.
Lesson 2						
Probing	14.09	6.39	18.08	9.50	24.40	12.18
Redirection	17.46	6.07	25.83	10.33	28.28	15.19
Praise	5.83	6.13	8.12	7.09	8.80	10.20
Feedback	11.71	5.91	15.79	8.12	16.05	6.44
Gives Answer	1.33	1.29	2.42	2.56	2.65	2.48
Lesson 7						
Probing	14.73	4.17	18.40	7.62	28.25	13.20
Redirection	16.50	7.23	22.65	10.00	30.25	13.37
Praise	4.86	3.73	6.45	5.19	4.96	4.56
Feedback	10.18	4.91	13.30	7.15	16.83	6.20
Gives Answer	2.00	1.94	1.45	1.40	2.08	1.76

* HCQ = Higher Cognitive Questioning

between themselves. The progression can be explained in terms of the opportunity for praise and feedback and for giving answers in the 50% HCQ and 75% HCQ treatments, compared to the 25% HCQ treatment. Nonetheless, inspection of the standard deviations for the treatment means indicates considerable overlap in the range of use of the behaviors among the treatments.

Adherence to treatment conditions for the art activity treatment was monitored by staff observations of randomly selected lessons. (The audiotape procedures were not used because few verbal events occurred that could be scored in a manner that was meaningful to the study.) Generally the prescribed conditions were maintained.

Average length of treatment sessions. In Study II the ecology teachers were asked to maintain a diary in which they recorded the length of each treatment session they taught. These times were compiled and summarized in order to determine how closely the average times approximated the pre-study estimates for each discussion treatment: 17 minutes for 25% HCQ treatment, 23 minutes for 50% HCQ treatment, and 29 minutes for 75% HCQ treatment. No analysis was necessary for the art activity treatment since each session was stopped at the end of 29 minutes.

Table 24 contains the estimated times for each discussion treatment for each teacher. These times are for the discussion portion of the treatment only. They do not include the additional 12 minutes of filler activity that occurred in the 25% HCQ treatment or the 6 minutes of filler activity for the 50% HCQ treatment. The filler activity time must be added to the average length of discussions to obtain the total time for these two treatments. Based upon the mean times for the treatments over all teachers and lessons, the average times for the various

TABLE 24

Study II

Average Length of Discussion Treatment Sessions

Teacher	25% Higher Cognitive Questions		50% Higher Cognitive Questions		75% Higher Cognitive Questions	
	$\overline{X}$ Frequency	S.D.	$\overline{X}$ Frequency	S.D.	$\overline{X}$ Frequency	S.D.
1	17.56	1.01	21.89	3.59	28.56	4.44
2	15.56	2.79	21.00	1.73	26.89	3.06
3	15.14**	3.24	22.63*	1.60	29.22	2.05
4	16.22	1.72	22.44	2.79	27.00*	2.88
5	14.89	2.89	20.33	5.66	26.25*	4.59
6	17.11	1.45	22.38*	3.42	28.89	3.59
7	17.88*	4.02	24.75*	5.99	29.50*	4.11
8	15.43**	1.81	21.00**	4.24	27.14**	1.87
9	15.56	1.33	23.33	1.12	30.89	4.01
10	18.75*	1.39	24.25*	1.39	31.33	3.45
11	15.89	2.98	16.44	2.96	23.33	2.74
12	14.89	2.42	21.33	1.73	22.78	5.07
TREATMENT $\overline{X}$	16.24	1.28	21.81	2.15	27.65	2.66

NOTE: Mean based on nine lessons except when indicated by asterisk

* = 8 lessons; **= 7 lessons

discussions are very close to the expected times. Adding the filler activity time to the 25% HCQ and 50% HCQ treatments, the mean times for the treatments were as follows: 28.24 for the 25% HCQ treatment, 27.81 for the 50% HCQ treatment, and 27.65 for the 75% HCQ treatment.

Individual teachers fell somewhat below the expected times in some treatments. For example, on the average, teachers 5 and 12 were low in the 25% HCQ treatment, teacher 11 was low in the 50% HCQ treatment, and teachers 11 and 12 were low in the 75% HCQ treatment. If a teacher effect appears in the results for Study II, consideration should be given to the effects of these teachers.

CURRICULUM

The ten-lesson ecology curriculum used in Study I also was used in Study II. Details concerning the content, development, and pilot testing of this curriculum are included in the report of Study I (see pages 29 to 37 of this volume). A copy of the printed materials used in the curriculum is included in Volume II of the report.

STUDENTS AND TEACHERS

Students

The sixth grade was selected as the grade level at which Study II would be conducted in order to work with students who had developed sufficient reading skills to facilitate use of the ecology curriculum and also to utilize a student sample similar to the one which participated in Study I.

Study II was conducted in the Novato Unified School District, Novato, California. Recruitment procedures followed the same plan as in Study I (See page 39). A total of 12 sixth-grade classes, two in each of six schools, volunteered for Study II. A total of 371 students from these classes served as the sample for the study.

Since the reading level of the students was considered important to the use of the curriculum materials, the students' scores on a state-administered reading test, the Comprehensive Tests of Basic Skills, were examined. This test was administered at the beginning of the school year in which the study was conducted. Table 25 presents the mean score and grade equivalent for all students participating in the study.

TABLE 25

Study II

Mean Reading Scores of Students

VOCABULARY			COMPREHENSION			VOCABULARY PLUS COMPREHENSION		
$\bar{X}$	S.D.	Grade* Equiv.	$\bar{X}$	S.D.	Grade Equiv.	$\bar{X}$	S.D.	Grade Equiv.
30.46	(6.89)	6.0	33.26	(9.39)	6.2	63.72	(14.05)	6.2

* Grade equivalents obtained from Examiner's Manual, Comprehensive Tests of Basic Skills. Monterey, California: McGraw-Hill, 1968, pages 48-49.

Teachers

The same 12 teachers participated in Study II as were in Study I. These teachers were recruited from a group of 100 teachers selected at random from the substitute teacher list of the San Francisco Unified School District.

Teacher recruitment and training procedures are described on pages 39 to 41 of this volume.

INSTRUMENTATION

In order to study the effects of teacher use of higher cognitive questions upon student outcomes, two aspects of student performance were investigated:

(a) student achievement at both fact recall and higher cognitive levels and in terms of both written and oral modalities; and

(b) student attitudes regarding the various treatment parameters.

A total of seven achievement measures and six attitude measures were used in the study. Every student irrespective of treatment, completed the same set of tests with the exception of the treatment-specific attitude scales. With respect to the latter, the particular scale administered to the student depended upon the treatment in which he or she participated. Tables 26 and 27 list the achievement and attitude instruments, respectively, and provide information about the specific variables measured by each instrument and the point of administration in the study.

Since these instruments are the same measures used in Study I, the discussion of their purpose, format, and construction are not repeated here. This information is presented on pages 41 to 60 of the report. Additional statistical information concerning the instruments is included in Appendix C of this volume and in Volume IV. Copies of the instruments, scoring keys, and scoring manuals are contained in Volume III.

TABLE 26

Study II

Achievement Measures

INSTRUMENT	VARIABLES MEASURED	POINT OF ADMINISTRATION	APPROXIMATE TESTING TIME**
Comprehensive Tests of Basic Skills-Reading	Vocabulary; Comprehension	Pre*	52 minutes
Ecology Information Test	Amount of information about ecology	Pre, post, delayed	15 minutes
Oral Test	Ability to state orally opinions, predictions, solutions, inferences, etc.	Pre, post	10 minutes
Essay Test	Ability to state in writing opinions, predictions, solutions, inferences, etc. Ability to state in writing reasons and if-then relationships.	Pre, post	25 minutes
Population Test	Ability to state in writing opinions, predictions, solutions, inferences, etc. Ability to state in writing reasons and if-then relationships.	Delayed	25 minutes
Question-Generating Test: Paper-and-Pencil Measure	Ability to generate questions. Quality of questions generated.	Pre, post	20 minutes
Question-Generating Test: Oral Measure	Ability to generate questions. Quality of questions generated.	Pre, post	2 minutes

* Data collected by the participating school district, not by the researchers.

** These are average times for test administration. All tests except the Question Generating Test (Paper-and-Pencil Measure) were primarily power tests.

TABLE 27

Study II

Attitude Scales

SCALE	VARIABLES MEASURED	POINT OF ADMINISTRATION	APPROXIMATE TESTING TIME
Word Association Scale	Attitude toward Ecological Concerns	Pre, post	10 minutes
Gall-Crown Discussion Attitude Scale	Attitude toward Class Discussions Attitude toward Thought Questions	Pre, post	15 minutes
Ecology Unit Opinions	Attitude toward Treatment Group Peers Attitude toward Ecology Teacher Attitude toward Ecology Curriculum	Post	15 minutes
Ecology Discussion Attitude Scale	Attitude toward Discussion in Discussion Treatments Attitude toward Thought Questions in Discussion Treatments	Post	15 minutes
Ecology Art Project Scale	Attitude toward Art Activities in Art Activity Treatment	Post	10 minutes

Certain aspects of the instruments and/or their scoring and rating should be noted in order to aid in the interpretation of Study II findings. A discussion follows of these study-specific factors.

Achievement Measures

The achievement measures included one measure of general ability and six measures of fact and higher cognitive outcomes related to the ecology curriculum unit.

Comprehensive Tests of Basic Skills (CTBS). Student scores on the Vocabulary (40 items) and Comprehension (45 items) subscales of the CTBS (Form Q-Level 2) were obtained from the school district. The scores were based upon the results of the October 1973 statewide testing program.

In Study II, the correlation between the Vocabulary and Comprehension Scales was .52; the correlation of these scales with the combined scale (total reading score) was .90 and .76, respectively.

Other information concerning this instrument may be found in Chapter Three and in Volumes II and IV.

Ecology Information Test (EIT). The EIT was designed to measure students' acquisition of factual information in the ecology curriculum. In Study II, the test was formed into three subtests:

- Intentional Scale II. Consisted of eight items which measure recall of information covered in the discussion treatments. This scale, therefore, was intentional for 25, 50, and 75% higher cognitive question treatments. It was incidental for the art activity treatment.
- 25% HCQ Incidental Scale II. Consisted of seven items which were taken from fact questions asked in the 25% HCQ treatment. The items were incidental for all other treatments.
- Incidental Scale II. Consisted of ten items which were incidental for all treatments.

See Chapter Three and Tables C-1 and C-2 of Appendix C for further information. Also refer to Volumes III and IV.

Oral Test. For a discussion of test purpose, content, and rating procedures refer to Chapter Three of this volume. The correlations between the oral test variables are reported in Table C-3 of Appendix C, other technical data regarding the test are contained in Volume IV. Volume III includes a copy of the test and the scoring procedures.

Two additional features of the Oral Test need to be considered when interpreting the results of Study II. These are: (a) the rating procedures and interrater reliabilities; and (b) the effects of cues on the audiotape recordings of the students' responses which indicated whether the recording was a pre-or posttest. A discussion of these factors follows.

Rating Procedures. Six raters were trained to a satisfactory level of performance using a set of "training tapes." These raters then were randomly paired and each pair was randomly assigned a set of audiotapes to rate. Interrater reliability was calculated by the intraclass correlation coefficient across all pairs of raters. Separate coefficients were computed for pre and post tapes for Study II (and Study I). Coefficients for the Content Scale ranged from .80 to .84. For the Logical Extension Scale in Study II, the pretape and posttape coefficients were .64 and .77, respectively.

Effects of Cues. Although the raters were not told which classroom or treatment group they were rating, the audiotapes contained some statements by the tester which identified the point of test administration.

For example, a tester might remark, "Don't worry; you'll learn more about this later." Raters were instructed to note on their forms when such an indicator occurred.

The rating forms were analyzed to determine the frequency and distribution of these indicators. Such indicators occurred more often than would be desired in Study II. However, the distribution of the occurrences was fairly even across the treatment conditions. Table 28 presents these data.

TABLE 28

Study II

Percentage of Oral Test Tapes Having Pre-Post Indicator

TREATMENT	PERCENTAGE OF TESTS HAVING PRE-POST INDICATOR	
	Pre	Post
25% HCQ*	4%	47%
50% HCQ	0	44%
75% HCQ	4%	41%
Art Activity II	1%	41%

*HCQ = Higher Cognitive Question

A supplemental analysis was done to determine whether the indicators influenced raters to assign higher or lower scores than when the indicators were not present. The analysis compared the raters' mean rating of indicator posttapes with their mean rating of non-indicator posttapes within the same treatment. The results are shown in Table 29.

TABLE 29

Study II

Comparison of Oral Test Posttest Ratings for
"Post" Indicator Present Versus "Post" Indicator Absent

		25% HCQ TREATMENT				50% HCQ TREATMENT				75% HCQ TREATMENT				ART ACTIVITY TREATMENT			
Variable	Indicator	Number of Tapes	$\overline{X}$ Rating	S.D.	t	Number of Tapes	$\overline{X}$ Rating	S.D.	t	Number of Tapes	$\overline{X}$ Rating	S.D.	t	Number of Tapes	$\overline{X}$ Rating	S.D.	t
LOGICAL EXTENSION SCALE	Present	30	4.52	2.36	2.29*	30	3.97	3.22	0.19	28	2.68	2.01	1.11	52	3.34	2.97	1.87
	Absent	38	3.30	1.97		38	3.84	2.25		40	3.44	3.15		84	2.56	1.87	
CONTENT SCALE	Present	31	9.24	3.18	1.34	30	8.67	2.67	0.82	30	7.63	2.41	1.45	53	8.22	3.00	3.36*
	Absent	39	8.33	2.42		39	9.23	2.86		41	8.74	3.58		88	6.73	2.2.	

*$p < .05$

As indicated in Table 29, the raters scored the posttapes with a post indicator higher than the posttapes without such an indicator on 5 of the 8 comparisons. Two of these comparisons indicated a statistically significant difference in the ratings at the .05 level. In Study II, therefore, presence of a post indicator needs to be taken into account in interpreting the results of the Oral Test. Even though the indicators were fairly equally distributed across the treatments, the effects of these indicators upon the students' posttest scores may contribute to any differences in treatment effects that occur.

Essay Test. The fourth achievement measure was the Essay Test. The purpose of this test was to measure students' ability to give plausible, reasoned, written responses to questions about the ecology curriculum. The test contained only questions requiring more than simple recall of information. The relationship of the questions to the Study II curriculum and the treatment conditions is presented in Table 30.

Additional information on this test may be found in Chapter Three, Table C-4 of Appendix C, and in Volumes III and IV of this report.

Transfer (Population) Test. See Chapter Three and Volumes III and IV of this report for information on this test.

Question Generating Test (Paper and Pencil). See Chapter Three and Tables C-5 and C-6 of Appendix C of this volume and Volumes III and IV of this report for information on this test.

Question Generating Test (Oral). The Oral Question Generating Test was similar to the written version except that the students responded orally. Audiotapes were made of the students' responses. Each audiotape was rated for frequency of non-pertinent and pertinent questions and for overall quality.

TABLE 30

Study II

Derivation of Essay Test Items

ITEM NO. CLASSIFICATION	TREATMENT AND/OR CURRICULUM SOURCE
1. Generalization	Incidental question (not included in any discussion treatment). Pertains to content of Lesson 7.
2. Generalization	Modified version of a question which appeared in all discussion treatments for Lesson 7.
3. Generalization	Modified version of a question which appeared in the 75% HCQ treatment for Lesson 8.
4. Opinion	Incidental question. Pertains to content of Lesson 5.
5. Interpretation	Intentional question for all discussion treatments for Lesson 4.
6. Solution	Incidental question. Pertains to content of Lesson 3.
7. Explanation	Modified version of a question which appeared in the 75% HCQ treatment for Lesson 7.
8. Opinion	Modified version of a question which appeared in the 75% HCQ treatment for Lesson 5.
9. Opinion	Modified version of a question which appeared in all discussion treatments for Lesson 6.
10. Prediction	Modified version of a question which appeared in all discussion treatments for Lesson 2.
11. Solution	Modified version of a question which appeared in the 75% HCQ treatment for Lesson 1.
12. Opinion	Incidental question. Pertains to content of Lesson 1.

Interrater reliability for Study II based upon interclass correlations across all raters ranged from .84 to .92 for pertinent questions; .80 to .86 for the overall quality rating; and .46 to .50 for nonpertinent questions. The coefficients for nonpertinent questions are somewhat low. However, in view of the low frequency of occurrence and the low range of scores for this variable, they are satisfactory.

As with the Oral Test, ratings of this variable are susceptible to the presence of "post" indicators on the audiotapes. Table 31 presents the analysis of the effects of the post indicators. Presence of an indicator results in higher ratings than when no indicator is given in nine of the twelve comparisons that were made. Two of these comparisons showed statistically significant differences favoring the tapes with indicators. Thus, results related to this variable also must be interpreted with the biasing effects of the indicators in mind. Differences among treatments may be affected by the "post" indicators as well as by treatment conditions. It should be recalled, however, that the indicators were fairly equally distributed across treatments so the bias may not be as critical as if it were concentrated in a particular treatment group.

Attitude Scales

Five attitude measures were administered in Study II. Three of these measures were administered to all students regardless of the treatment group to which they were assigned. They were the Word Association Scale, Gall-Crown Discussion Attitude Scale, and the Ecology Unit Opinion Scale. Two of the measures assessed students' attitude toward the specific treatment in which they participated. They were the Ecology Discussion Attitude Scale and the Ecology Art Project Scale.

TABLE 31

Study II

Comparison of Question Generating Test (Oral) Posttest Ratings for "Post" Indicator Present Versus "Post" Indicator Absent

		25% HCQ TREATMENT				50% HCQ TREATMENT				75% HCQ TREATMENT				ART ACTIVITY TREATMENT II			
Variable	Indicator	Number of Tapes	$\overline{X}$ Rating	S.D.	t	Number of Tapes	$\overline{X}$ Rating	S.D.	t	Number of Tapes	$\overline{X}$ Rating	S.D.	t	Number of Tapes	$\overline{X}$ Rating	S.D.	t
NON-PERTINENT QUESTIONS	Present	31	0.05	0.15	0.46	30	0.35	0.83	2.05*	30	0.21	0.51	1.98*	53	0.16	0.42	0.46
	Absent	39	0.08	0.33		39	0.06	0.23		41	0.05	0.04		88	0.13	0.34	
PERTINENT QUESTIONS	Present	31	[illegible].98	1.29	0.73	30	1.95	1.40	0.38	30	1.48	0.90	0.57	53	1.87	1.84	1.46
	Absent	39	1.73	1.49		39	1.82	1.38		41	1.66	1.53		88	1.47	1.38	
QUALITY RATING	Present	31	1.05	0.53	0.07	30	1.17	0.58	0.69	30	1.10	0.74	0.45	53	0.91	0.69	1.02
	Absent	39	1.04	0.65		39	1.06	0.70		41	1.02	0.72		88	1.07	1.00	

$p \leq .05$

Information concerning each of these instruments is reported in Chapter Three, Tables C-8 through C-16 of Appendix C, and in Volumes III and IV of the report.

RESEARCH DESIGN OF STUDY II

The purpose of Study II was to test the effects of four instructional treatments on student achievement and attitudes.

Study II employed the same Latin square design as Study I. The reasons for selecting this design and the application of the design to the study are discussed on pages 61 to 62.

Assignment of Schools and Classrooms

Study II was conducted in a single school district using two sixth-grade classrooms from each of six schools. The study was conducted by the same twelve ecology teachers as Study I. The complete design for Study II is presented in Table 32.

The same procedures used in Study I (see page 64) were followed to assign the six schools and twelve classrooms of School District II to squares as shown in Table 32. Basically, each of the schools provided two sixth-grade classrooms for the study. Schools were paired, and each pair formed a separate Latin square with four classrooms. There were a total of three such Latin squares.

Assignment of Teachers to Latin Squares

The same twelve ecology teachers as in Study I participated in Study II. However, unlike Study I they could not be randomly assigned to Latin square

TABLE 32

Study II
Composition of Squares

SQUARE 1

ECOLOGY TEACHER	SCHOOL 7		SCHOOL 8	
	9AM* Class 13	10:00AM Class 14	12:30PM Class 15	2:00PM Class 16
8	Treatment 6 B=3 G=3	Treatment 8 B=3 G=3	Treatment 9 B=5 G=6	Treatment 7 B=3 G=3
7	Treatment 8 B=3 G=3	Treatment 7 B=3 G=3	Treatment 6 B=3 G=3	Treatment 9 B=5 G=4
10	Treatment 9 B=2 G-11	Treatment 6 B=3 G=3	Treatment 7 B=3 G=3	Treatment 8 B=3 G=3
12	Treatment 7 B=3 G=3	Treatment 9 B=6 G=9	Treatment 8 B=3 G=3	Treatment 6 B=3 G=3

SQUARE 2

ECOLOGY TEACHER	SCHOOL 9		SCHOOL 10	
	9:00AM Class 17	10:00AM Class 18	12:30PM Class 19	2:00 PM Class 20
4	Treatment 6 B=3 G=3	Treatment 8 B=3 G=3	Treatment 7 B=3 G=3	Treatment 9 B=8 G=7
11	Treatment 8 B=3 G=3	Treatment 7 B=3 G=3	Treatment 9 B=8 G=7	Treatment 6 B=3 G=3
1	Treatment 9 B=6 G=6	Treatment 6 B=3 G=3	Treatment 8 B=3 G=3	Treatment 7 B=3 G=3
5	Treatment 7 B=3 G=3	Treatment 9 B=3 G=7	Treatment 6 B=3 G=3	Treatment 8 B=3 G=3

SQUARE 3

ECOLOGY TEACHER	SCHOOL 11		SCHOOL 12	
	9:00AM Class 21	10:00AM Class 22	12:30PM Class 23	2:00PM Class 24
6	Treatment 6 B=3 G=3	Treatment 8 B=3 G=3	Treatment 9 B=7 G=7	Treatment 7 B=3 G=3
2	Treatment 8 B=3 G=3	Treatment 7 B=3 G=3	Treatment 6 B=3 G=3	Treatment 9 B=6 G=8
3	Treatment 7 B=3 G=3	Treatment 9 B=6 G=7	Treatment 8 B=3 G=3	Treatment 6 B=3 G=3
9	Treatment 9 B=7 G=7	Treatment 6 B=3 G=3	Treatment 7 B=3 G=3	Treatment 8 B=3 G=3

*Times are approximate.

Treatment 6 = 25% Higher Cognitive Questions
Treatment 7 = 50% Higher Cognitive Questions
Treatment 8 = 75% Higher Cognitive Questions
Treatment 9 = Art Activity
B = Boys
G = Girls

blocks due to logistical constraints. Since teachers formed car pools to drive to School District II, they were assigned to schools, and thus blocks, on the basis of the proximity of their residence to other teachers. Although not random in the usual sense, the arbitrary criterion of proximity to other teachers suggests that this procedure was unlikely to generate study-related bias in the assignment of ecology teachers to blocks.

Assignment of Treatments to Ecology Teachers

The same procedures used in Study I (see page 66) were followed to assign the twelve ecology teachers to the four Study II treatments. The basic procedure was that, after the teachers had been assigned to squares, they were randomly assigned to cells in their respective squares. The result was that each teacher conducted the four different treatments in the four classrooms during each school day.

Assignment of Students to Treatments

Discussion treatments with approximately equal numbers of boys and girls were desired. Thus, each class was stratified with respect to sex of students. Boys were randomly assigned to the discussion treatments until there were three boys in each treatment. The remaining boys were assigned to the art activity group. The same procedure was used to assign girls to treatments.

Table 32 presents the results of this assignment procedure. Since each classroom had a different class size and sex distribution, the composition of the art activity groups across the twelve classrooms varied in size and in proportion of boys and girls.

As in Study I, the student's regular teachers were asked whether any of the treatment groups contained students who became highly disruptive when placed in proximity to each other. Such students were reassigned to another treatment. As in Study I, the frequency of reassignments was low, on the average of about one per classroom.

STATISTICAL ANALYSIS

Introduction

The data collected in the Latin square design of Study II were examined by the same analysis of variance methods used in Study I. As in the first study, Study II was planned to provide a comparison among four instructional treatments: 25% HCQ, 50% HCQ, 75% HCQ, and Art Activity. There was a total of 12 classrooms, four for each of the Latin squares, and there were also 12 ecology teachers, four assigned to each Latin square.

The rationale for the unit of analysis, the use of univariate analysis of variance, planned comparisons, statistical adjustment procedures, and treatment of missing data are the same as in Study I. Therefore, the reader is referred to pages 67-74 for discussion of these topics.

The following sections are concerned with statistical adjustment procedures and post-hoc comparisons as they apply specifically to Study II.

Adjustment Procedures

As in Study I, each dependent variable was examined for the possibility of adjusting for pre-experimental differences before performing the analysis of variance. Using adjusted scores provides assurance (beyond the assurance created by random assignment of students to treatments) that pretreatment differences do not contribute to posttreatment differences. Adjusted scores also have the benefit of increasing the precision of the analysis.

The adjusting variables were selected according to the same procedures and criteria as in Study I (see pages 67-70). Table 33 presents the information used to choose adjusting variables for posttreatment variables and the pooled slope estimates for those posttreatment variables which were adjusted.

After the adjusting variables had been selected, the appropriate cell means were adjusted in the analysis of variance.

Planned Comparisons

Each dependent variable measured by the test battery administered to all students in Study II was examined for the main effect of overall treatment differences in the analysis of variance. In addition, several planned comparisons of specific treatments were examined: (a) 25% HCQ treatment versus 50% HCQ treatment; (b) 25% HCQ treatment versus 75% HCQ treatment; (c) 50% HCQ treatment versus 75% HCQ treatment; and (d) the combined HCQ treatments versus Art Activity II. Where the main effect of instructional treatment is statistically significant, the planned comparisons will help identify the nature of these differences. Even where the overall treatment effect is not statistically significant,

TABLE 33

Study II
Summary of Statistics Used in Adjusting Posttreatment Variables

DEPENDENT VARIABLE	ADJUSTING VARIABLE	F FOR PARALLELISM OF REGRESSION	r	b_p
		$F_{1,\infty} = 2.60$		
Ecology Information Test:				
Intentional Scale II, Delayed	Total Reading	1.21	.42	.0627
25% Intentional Scale II, Post	Total Reading	1.03	.50	.0603
25% Intentional Scale II, Delay	Total Reading	.25	.39	.0494
Incidental Scale II, Post	Total Reading	.92	.53	.0861
Incidental Scale II, Delay	Total Reading	.68	.50	.0874
Oral Test:				
Content Scale, Post	Pre	.93	.44	.3894
Logical extension, Post	Pre	1.37	.62	.7922
Essay Test:				
Content Scale, Post	Pre	2.53	.65	.7002
Transfer Test:				
Content Scale, Delay	Essay content, Pre	.18	.62	.6174
Written Question-Generating Test:				
Pertinent Questions	Pre	1.03	.62	.7519
Word Association Scale:				
Wolf, Post	Pre	.54	.58	.6080
Alligator, Post	Pre	1.50	.53	.5251
Gall-Crown Discussion Attitude Scale:				
Thought, Post	Pre	1.16	.55	.6731
Discussion, Post	Pre	2.53	.58	.7051

examining comparisons will provide information about the more specific effects of discussion treatments.

Each comparison has one degree of freedom and was tested for significance using the mean square error term from the analysis of variance. For those dependent variables which were adjusted, these comparisons used adjusted cell means.

CHAPTER SIX

STUDY II RESULTS

The statistical analyses for Study II were planned in response to two research objectives:

1. to determine what student learning outcomes were affected by variations in the percentage of higher cognitive questions in discussions; and
2. to determine what student learning outcomes were affected by presence or absence of discussions.

As discussed earlier, four instructional treatments were designed to investigate these effects. In the 25% HCQ treatment, twelve groups of students participated in discussions in which 25 percent of the questions required a higher cognitive response (the other 75 percent required recall of information). In the 50% HCQ treatment, the percentage of higher cognitive questions was increased to 50 percent. Another twelve groups of students participated in this treatment. In the 75% HCQ treatment, the percentage of higher cognitive questions was increased to 75 percent. Another twelve groups of students participated in this treatment. The ecology teachers were instructed to probe and redirect student responses to the specified questions in each treatment. In the art activity treatment, twelve groups of students participated in curriculum-related art activities with no discussion.

The treatments were administered within a Latin square design by twelve ecology teachers to twelve sixth-grade classes in the same school district. Each student was administered a test battery before, immediately after, and/or two weeks after the treatments to determine the effects of the treatments on achievement and attitudes related to the specific curriculum which they had studied.

The following discussion presents the results of the experiment. It is organized in the same sequence as in the Results Section for Study I. The statistical tables also have the same format whenever possible.

First, the data for each dependent variable were examined by analysis of variance methods to determine statistical significance of the overall treatment effect. Groups within treatments rather than individual students were used as the unit of analysis.

Next the planned comparisons of treatment means for each dependent variable were completed. The purpose of these comparisons was to determine the statistical significance of the specific differences between treatment means. The comparisons included:

(a) the difference between the 25% HCQ treatment means and 50% HCQ treatment means;

(b) the difference between the 50% HCQ treatment means and the 75% HCQ treatment means; and

(c) the difference between the 25% HCQ treatment means and the 75% HCQ treatment means.

This analysis was designed to determine whether variations in percentage of higher cognitive questions in a discussion affected student learning outcomes.

A fourth planned comparison was between the three combined discussion treatment means and the art activity means. The purpose of this analysis was to determine whether presence or absence of discussions following initial reading/viewing of curriculum material affected student learning outcomes.

Following the planned comparisons, other effects examined by the analysis of variance are discussed. These include: class, ecology teacher, Latin square, and treatment by Latin square interaction.

As in Study I, the results are presented in three subsets for ease of interpretation. First, the achievement test data are discussed in terms of treatment main effects, planned comparisons of treatment means, and other analysis of variance effects. Next, the attitude scale data are discussed under the same headings. Finally, the status variables (verbal ability and session attendance) are discussed in the context of their possible influence on observed treatment differences.

Cell means used in the analysis are reported in Appendix E of this volume.

ACHIEVEMENT MEASURES

Table 34 presents the results of the analysis of variance for the ability, achievement, and attendance measures which were administered in Study II. Interpretation of column labels can be found in the discussion of Table 16 in the Study I report (see pages 77-79). To summarize briefly, this table contains the following information:

(a) the name of each dependent variable;

(b) name of adjusting variable, if any;

(c) the error mean square and its degrees of freedom;

(d) the F-statistics for each variable for the main effect of treatment, of class within squares, of teachers within squares, of squares, and the treatment by square interaction; and

(e) the strength of association statistics associated with the column's effect for each variable.

Main Effect of Treatment

Inspection of Table 34 in which results for the achievement measures are reported reveals that there were statistically significant differences at the 5 percent level between instructional treatment group means on the following variables:

- Ecology Information Test Intentional Scale II (post and delayed)
- Ecology Information Test 25% Intentional Scale (post and delayed)
- Ecology Information Test Incidental Scale II (post and delayed)
- Oral Test Content Scale (post)
- Oral Test Logical Extension Scale (post), and
- Essay Test Content Scale (post).

None of the variables derived from the Transfer Test or question-generating measures yielded a significant treatment effect. It is interesting to note, based upon these results, that the treatments seem to have had more influence upon recall of information than upon the various higher level outcomes. For example, all the information test subscales emphasize factual knowledge and the content scales of the oral and essay tests, while requiring higher cognitive responses, build these responses from the actual content of the questions asked during the discussions. Further, the lack of differences in the oral question generating tests and the relatively low scores achieved by the students on all but the pertinent question subscale of these measures (see Appendix E for cell means) suggest that students were having some difficulty moving beyond the actual content of the curriculum and the discussion questions. Planned comparisons to determine which of the treatment means differed significantly from each other on these achievement variables are presented in the next section.

TABLE 34

Study II

Analysis of Variance Summary for Measures of Ability, Achievement, and Attendance

DEPENDENT VARIABLE	ADJUSTING VARIABLE	MSerror df=18	F VALUES AND ω^2 FOR ANALYSIS OF VARIANCE EFFECTS									
			Treatment		Class		Teacher		Square		Treatment by Square	
			$F_{3,18}$	ω^2	$F_{9,18}$	ω^2	$F_{9,18}$	ω^2	$F_{2,18}$	ω^2	$F_{6,18}$	ω^2
STATUS VARIABLES												
Number of Sessions Attended		0.51	0.18	0.00[a]	0.46	0.00	0.96	0.00	1.49	0.02	1.11	0.01
CTBS[b] - Total Reading		48.25	0.53	0.00	1.38	0.02	0.82	0.00	0.93	0.00	1.01	0.00
KNOWLEDGE VARIABLES												
Ecology Information Test:												
Intentional Scale II, post		0.33	8.55*	0.31	1.42	0.05	1.08	0.01	0.72	0.00	0.69	0.00
Intentional Scale II, delay	total rdng.	0.40	12.51*	0.42	0.77	0.00	0.92	0.00	3.85*	0.07	0.57	0.00
25% Intentional Scale II, post	total rdng.	0.35	9.46*	0.40	1.[illegible]0	0.00	0.54	0.00	0.48	0.00	0.28	0.00
25% Intentional Scale II, delay	total rdng.	0.49	5.20*	0.25	0.75	0.04	0.42	0.00	0.54	0.00	0.73	0.00
Incidental Scale II, post	total rdng.	0.48	7.49*	0.27	1.60	0.07	0.88	0.00	2.37	0.04	1.57	0.05
Incidental Scale II, delay	total rdng.	0.68	7.30*	0.28	1.57	0.05	0.49	0.00	1.86	0.03	0.90	0.00
HIGHER COGNITIVE VARIABLES												
Oral Test:												
Content, post	pre	1.10	6.53*	0.19	0.42	0.00	0.73	0.00	9.88*	0.25	2.12	0.15
Logical Extension, post	pre	0.68	4.91*	0.13	3.49*	0.25	1.19	0.02	3.22	0.05	1.42	0.03
Essay Test:												
Content, post	pre	1.19	8.19*	0.14	9.77*	0.52	1.36	0.02	1.57	0.01	0.97	0.00
Logical Extension, post		0.71	1.18	0.01	2.49*	0.27	0.35	0.00	0.15	0.00	0.34	0.00
Transfer Test:												
Content, delay	Ess.Cont.pre	2.29	0.32	0.00	1.75	0.15	0.34	0.00	1.78	0.04	0.58	0.00
Logical Extension, delay		0.39	0.64	0.00	3.32*	0.32	1.24	0.03	1.03	0.00	0.36	0.00
QUESTION GENERATING VARIABLES												
Written Question Generating Test:												
Non-pertinent Questions		0.16	1.08	0.00	1.41	0.07	0.77	0.00	2.29	0.05	0.74	0.00
Pertinent Questions	pre	3.52	2.81	0.04	7.63*	0.43	1.33	0.02	15.10*	0.20	0.33	0.00
Specific Questions		1.53	2.66	0.07	3.95*	0.36	0.40	0.00	0.50	0.00	1.02	0.00
Request for Rationale		0.18	0.37	0.00	0.61	0.13	0.65	0.00	0.27	0.00	0.21	0.00
Quality Rating		0.06	0.51	0.00	1.75	0.14	0.90	0.00	0.83	0.00	0.36	0.00
Oral Question Generating Test:												
Non-pertinent Questions		0.03	1.23	0.00	1.61	0.05	0.98	0.00	3.86*	0.08	1.41	0.02
Pertinent Questions		0.45	0.61	1.00	0.66	0.00	0.98	0.00	0.49	0.00	1.22	0.03
Quality Rating		0.07	0.12	0.00	1.24	0.05	0.47	0.00	3.35	0.11	0.32	0.00

*Significance at the .05 level. The .05 levels for F values with the following degrees of freedom are:
$F_{2,18}$=3.55 $F_{3,18}$=3.16 $F_{6,18}$=2.66 $F_{9,18}$=2.45

[a] ω^2 = proportion of total variance explained (omega squared).

[b] CTBS= Comprehensive Tests of Basic Skills.

Omega squared values for the effect of treatment range from .00 to .42 with seven values exceeding .15. It is noteworthy that the omega squared values for treatment associated with the knowledge variables (Ecology Information Test) are quite large. In the other variable categories, the low omega squared values further suggest that the effect of the treatments in Study II on higher cognitive response skills and question generating skill was small.

Planned Comparisons of Treatment Means

Table 35 presents the planned comparisons of treatment means. The table lists each of the status and achievement test variables in the first column. The next four columns present all means for each treatment in the Latin square design: 25% HCQ, 50% HCQ, 75% HCQ, and Art Activity, respectively. For variables which were adjusted before entry into the analysis of variance, the values shown in these columns are adjusted means. A reference number in parentheses associated with each treatment is used in labeling the columns for planned comparisons.

The next four columns present F-statistics for the planned comparisons of treatment group means or adjusted means. The first of these columns compares the 25% HCQ treatment with the 50% HCQ treatment (1 vs. 2); the second column compares the 50% HCQ treatment with the 75% HCQ treatment (2 vs. 3); and the third column compares the 25% HCQ treatment with the 75% HCQ treatment (1 vs. 3). The fourth column compares the average effect of the three discussion treatments with the no-discussion art activity treatment.

In the column labeled "Prop," the ratio of sum of squares for the contrast to sum of squares for the main effect of treatments is presented.

TABLE 35

STUDY II

Treatment Means and Planned Comparisons of Measures of Ability, Achievement, and Attendance

DEPENDENT VARIABLE	ADJUSTING VARIABLE	TREATMENT MEANS				PLANNED COMPARISONS				
		25% HCQ Treatment (1)	50% HCQ Treatment (2)	75% HCQ Treatment (3)	Art Activ. II (4)	Treatments 1 vs 2 $F_{1,18}$	Treatments 2 vs 3 $F_{1,18}$	Treatments 1 vs 3 $F_{1,18}$	Treatments 1,2,3 vs 4 $F_{1,18}$	Prop.[a]
STATUS VARIABLES										
Number of Sessions Attended		9.23	9.04	9.17	9.21	0.45	0.19	0.06	0.07	0.13
CTBS[b] - Total Reading		61.69	64.71	61.85	63.63	1.13	1.10	0.00	0.14	0.09
KNOWLEDGE VARIABLES										
Ecology Information Test:										
Intentional Scale II, post		6.27	5.94	6.29	5.26	2.01	2.21	0.00	22.83*	0.89
Intentional Scale II, delay	total rdng.	6.19	5.26	5.85	4.74	13.12*	5.31*	1.73	24.10*	0.48
25% Intentional Scale II, post	total rdng.	4.68	3.53	4.01	3.62	22.96*	3.97	7.83*	5.21*	0.18
25% Intentional Scale II, delay	total rdng.	4.52	3.56	3.76	3.56	11.59*	0.50	7.30*	2.67	0.47
Incidental Scale II, post	total rdng.	5.97	4.92	5.83	5.00	13.66*	10.29*	0.24	6.34*	0.28
Incidental Scale II, delay	total rdng.	5.91	4.52	5.34	4.67	17.22*	5.97*	2.91	4.49*	0.21
HIGHER COGNITIVE VARIABLES										
Oral Test:										
Content, post	pre	8.88	8.83	8.42	7.35	0.01	0.96	1.17	15.15*	0.91
Logical Extension, post	pre	4.03	3.80	3.10	2.95	0.50	4.30	7.73*	6.39*	0.43
Essay Test:										
Content, post	pre	11.58	12.55	11.64	10.36	4.73*	4.11	0.02	18.54*	0.76
Logical Extension, post		2.11	2.30	2.03	1.68	1.34	0.62	0.04	2.89	0.81
Transfer Test:										
Content, delay	Ess.Cont.pre	8.79	8.99	8.62	8.40	0.10	0.07	0.61	0.61	0.64
Logical Extension, delay		1.67	1.73	1.85	1.51	0.07	0.22	0.55	1.37	0.72
QUESTION-GENERARING VARIABLE										
Written Question Generating Test:										
Non-pertinent Questions		0.37	0.43	0.61	0.34	0.11	1.28	2.15	0.86	0.27
Pertinent Questions	pre	12.48	13.51	12.52	11.29	1.80	1.68	0.00	6.12*	0.73
Specific Questions		3.24	4.16	3.12	2.81	3.36	4.25	0.05	2.87	0.36
Request for Rationale		0.56	0.51	0.42	0.39	0.08	0.29	0.65	0.42	0.38
Quality Rating		2.94	2.98	2.86	2.94	0.21	1.48	0.57	0.02	0.01
Oral Question Generating Test:										
Non-pertinent Questions		0.18	0.11	0.14	0.14	3.49	1.17	0.62	0.17	0.05
Pertinent Questions		1.85	1.87	1.56	1.64	0.00	1.25	1.11	0.27	0.15
Quality Rating		1.06	1.10	1.05	1.02	0.07	0.19	0.03	0.17	0.46

*Significance at the .05 level. The .05 level for F values with 18 degrees of freedom is: $F_{1,18} = 4.41$

[a] Prop. = Sum of squares for Treatments 1, 2, 3 vs 4 as a proportion of total treatment sum of squares.

[b] CTBS = Comprehensive Tests of Basic Skills.

Additional details about the construction of this table are presented in the discussion of the corresponding Table (17) in the Study I report, on page 81.

The planned comparisons of treatment means show that percentage of higher cognitive questions was a statistically significant influence on the amount of information acquired by students as measured by subscales on the Ecology Information Test. The pattern of treatment mean scores is depicted in Figure 2. It appears that a U curve describes the relation between percentage of higher cognitive questions and achievement on intentional and incidental scales of the Ecology Information Test. In all cases, the 50% HCQ treatment had considerably lower outcomes on the subscales of the Ecology Information Test than the other two discussion treatments. The 75% HCQ and 25% HCQ treatment outcomes fell at similar points for the various subtests. Outcomes for the art activity treatment approximated those for the 50% HCQ.

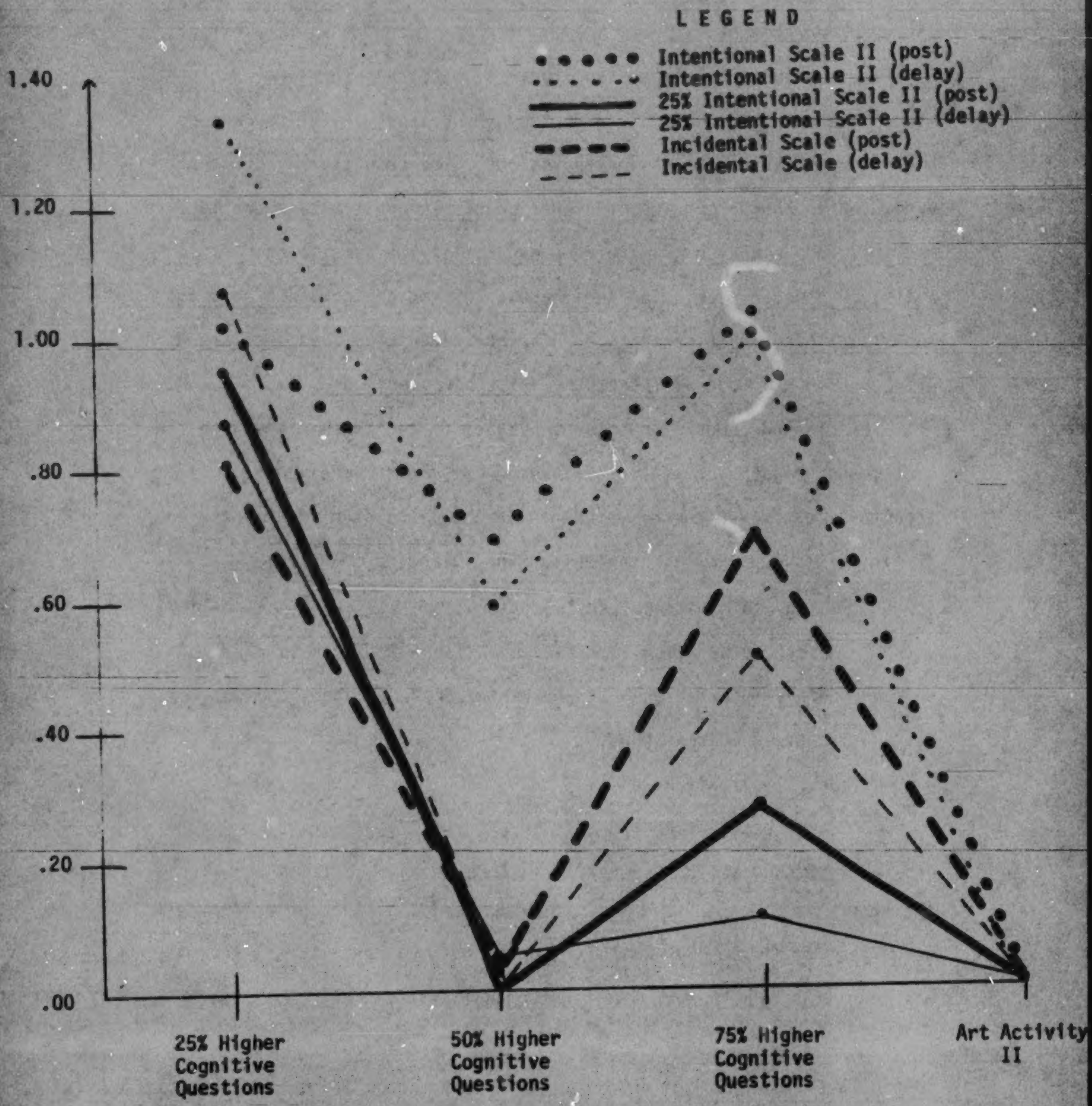
Since this finding was somewhat unexpected--a gradual increase in outcomes moving from the art activity to 25% HCQ, to 50% HCQ, with 75% being highest was expected--a secondary analysis of the data has been requested. This analysis is being conducted by Dr. Richard Snow, Stanford University. The purpose of the secondary analysis is to identify possible explanations for the U curve in order to aid in interpreting and applying the results of Study II. The report of the secondary analysis will be presented in a separate document.

Overall, the effects of treatment variations in Study II were nonsignificant for the other higher cognitive achievement measures. The only exceptions to this observation are that the 25% HCQ treatment groups achieved statistically greater Oral Test Logical Extension scores relative

FIGURE 2

Patterns of Treatment Differences for

Ecology Information Subtests in Study II



*Data points on the graph are based on unadjusted treatment means. The three recitation treatment means are expressed on the ordinate as absolute deviations from the art activity treatment means. The latter means serve to the 75% HCQ treatment groups; and that the 50% HCQ treatment groups achieved statistically greater Essay Test Content scores than did the 25% HCQ treatment groups.

These results relate to the Study II objective of determining what student learning outcomes are affected by variation in the percentage of higher cognitive questions in discussions. The results indicate that variation in the percentage of higher cognitive questions generally does not influence higher cognitive response ability or question-generating ability. However, variation does have an effect on knowledge acquisition such that low or high percentages of higher cognitive questions are more effective than a moderate percentage of these questions.

The planned comparisons of the average of the three discussion treatment means on each achievement variable with the respective art activity treatment mean revealed that students in the discussion treatments had statistically superior achievement on the following measures:

- Ecology Information Test Intentional Scale II (post and delayed)
- Ecology Information Test 25% Intentional Scale (post)
- Ecology Information Test Incidental Scale II (post and delayed)
- Oral Test Content (post)
- Logical Extension (post)
- Essay Test Content (post)
- Written Question-Generating Test Pertinent Questions (post).

The proportion of total between treatment variablity accounted for by the comparison of the higher cognitive questions treatments to Art Activity was moderate, ranging from .01 for the quality rating on the Written Question-Generating Test to .91 on the adjusted posttest score on the Content Scale of the Oral Test. Six of the 20 comparisons had a ratio greater than or equal to .65. Given the findings relative to the 50% HCQ treatment, it can be surmised that the majority of these differences may be attributed to the effects of the 75% HCQ and 25% HCQ treatments. As would be expected given the over-all treatment findings, the preponderance of differences were on those measures related to recall of information (the information tests and/or higher cognitive outcomes building from the content of the discussions and/or the curriculum). Study II discussions appear to help students remember curricular content better than when they merely read and/or hear about it.

These results relate to the research objective of determining which student learning objectives are affected by presence or absence of discusion. The results indicate that discussion of the type incorporated in the three Study II discussion treatments is more effective than a competing no-discussion treatment in facilitating knowledge acquisition and ability to respond to higher cognitive questions that build from the content of the curriculum both orally and in written form.

Classroom, Teacher, and Square Effects

Unlike Study I, there were few instances in which the analysis of variance effects for class, teacher, square and treatment by square were statistically significant, as presented in Table 34. Omega squared values were consistently small, ranging from .00 to .52 with only ten of the 120 statistics exceeding .15, of which six were associated with class effects. With the possible exception of the class effects for the achievement variables of Oral Test Logical Extension (post), Essay Test Content (post) and Logical Extension (post), Transfer Test Logical Extension (delay), and Written Question-Generating Test Pertinent Questions (post) and Specific Questions (post), these differences appear sporadic and of little value in interpreting the results of the study.

ATTITUDE MEASURES

Table 36 presents the results of the analysis of variance for scales derived from the following attitude measures: Word Association Scale, Gall-Crown Discussion Attitude Scale, Ecology Unit Opinions Scale, and Ecology Discussion Attitude Scale.*

The table is organized according to the same format as the preceding table. Details about the table's construction and labels are presented on pages 91 - 93 of the Study I report.

Main Effect of Treatment

Table 36 indicates that the overall treatment effect was statistically significant for only two attitude scales (Wolf and Alligator scales of the Word Association Scale). Because of the large number of comparisons (14), approximately one difference would be expected to occur by chance alone rather than reflect a true difference between means.

Planned Comparisons

Planned comparisons involving the differential effect of treatments on attitude scales are presented in Table 37. This table is organized according to the same format as Table 34, which presents planned comparisons involving the achievement variables of Study II. Details about the construction and labeling of this table are presented in the Study I report on pages

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* Analysis of variance for the two subscales derived from the Ecology Discussion Attitude Scale included only the three discussion treatments. This measure was not administered to students in the art activity treatment since they did not participate in ecology discussions.

TABLE 36

Study II

Analysis of Variance of Attitude Scale Scores

DEPENDENT VARIABLE	ADJUSTING VARIABLE	MSerror df=18	F VALUES AND ω^2 FOR ANALYSIS OF VARIANCE EFFECTS									
			Treatment		Class		Teacher		Square		Treatment by Square	
			$F_{3,18}$	ω^2	$F_{9,18}$	ω^2	$F_{9,18}$	ω^2	$F_{2,18}$	ω^2	$F_{6,18}$	ω^2
CURRICULUM-RELATED VARIABLES												
Word Association Scale												
Ecology		30.97	0.48	0.00[a]	1.14	0.03	0.80	0.00	1.17	0.00	0.79	0.00
Balance of Nature		16.51	1.94	0.05	0.96	0.00	0.79	0.00	0.39	0.00	1.87	0.09
Wolf	pre	10.13	6.33*	0.23	0.65	0.00	1.55	0.07	0.80	0.00	1.64	0.05
Air Pollution		6.51	0.48	0.00	0.34	0.00	0.59	0.00	1.02	0.00	0.57	0.00
Alligator	pre	10.62	7.40*	0.27	1.84	0.10	0.66	0.00	0.19	0.00	0.81	0.00
Water Pollution		6.76	0.53	0.00	0.72	0.00	0.75	0.00	4.21*	0.12	1.44	0.05
DISCUSSION VARIABLES												
Gall-Crown Dis.Attitude Scale:												
Att.toward Thought Questions	pre	4.54	1.38	0.02	0.54	0.00	0.95	0.00	1.26	0.01	2.24	0.14
Attitude toward Discussion	pre	22.44	0.65	0.00	1.23	0.04	0.45	0.00	1.29	0.01	1.73	0.09
GENERAL TREATMENT VARIABLES												
Ecology Unit Opinions Scale:												
Attitude toward Peers		1.69	2.55	0.08	1.04	0.00	0.64	0.00	0.37	0.00	1.63	0.07
Attitude toward Teacher		10.88	0.21	0.00	0.61	0.00	1.46	0.08	1.24	0.01	1.07	0.00
Attitude toward Curriculum		5.77	0.29	0.00	0.53	0.00	1.35	0.06	3.49	0.10	0.43	0.00
TREATMENT-SPECIFIC VARIABLES												
Ecology Discussion Attitude Scale												
Att.toward Thought Questions		14.74	0.04	0.00	0.78	0.00	0.64	0.00	0.67	0.00	0.15	0.00
Attitude toward Discussion	GDAS.pre-dsc	19.71	0.11	0.00	0.64	0.00	1.15	0.02	7.67*	0.28	0.48	0.00
Ecology Art Project Scale												
Attitude toward Art Projects												

*Significance at the .05 level. The .05 level for F values with the following degrees of freedom are:

$F_{2,18}=3.55$ $F_{3,18}=3.16$ $F_{6,18}=2.66$ $F_{9,18}=2.45$

[a] ω^2 = proportion of total variance explained (omega squared).

Planned comparisons of discussion treatment means on the attitude measures are significant only for the Alligator scale. The mean of the 75% HCQ treatment groups was significantly greater than the mean of the 50% HCQ treatment groups. This is one of the dependent variables which showed an overall treatment effect in the analysis presented directly above. However, in view of the large number of planned comparisons, this difference is quite likely a chance result.

These results relate to one of the research objectives of Study II; that is, to determine which student learning outcomes are affected by variation in the proportion of higher cognitive questions in discussions. The results indicate that variation in percentage of higher cognitive questions does not affect student attitudes toward curriculum-related topics, toward discussions in general, or toward the specific learning experiences in which these variations were tested.

The planned comparisons of the average of the three discussion treatments versus the art activity treatment revealed significant differences for the same two scales (Wolf and Alligator) as in the preceding analysis. Students in the discussion treatments expressed significantly more positive attitudes toward alligators and wolves than did students in the art activity treatment. It should be noted that each of the discussion treatments had slightly higher means than the art activity treatment on two other of the six scales included in the Word Association Scale, although the differences were not statistically significant. One subscale of the Ecology Unit Opinions Scale (Attitude toward Peers) also revealed a significant difference favoring the discussion treatments.

As noted in the presentation of Study I results (see page 96), the mean scores of the different treatment-specific attitude scales cannot be

TABLE 37

Study II

Treatment Means and Planned Comparisons of Attitude Measures

DEPENDENT VARIABLE	ADJUSTING VARIABLE	TREATMENT MEANS				PLANNED COMPARISONS				
		25% HCQ Treatment	50% HCQ Treatment	75% HCQ Treatment	Art Activ. II	Treatments 1 vs 2	Treatments 2 vs 3	Treatments 1 vs 3	Treatments 1,2,3 vs 4	
		(1)	(2)	(3)	(4)	$F_{1,18}$	$F_{1,18}$	$F_{1,18}$	$F_{1,18}$	Prop.
CURRICULUM RELATED VARIABLES Word Association Scale: Ecology		62.49	63.01	64.51	61.91	0.05	0.43	0.79	0.59	0.41
Balance of Nature		59,73	59.40	61.41	57.93	0.04	1.48	1.02	4.12	0.71
Wolf	pre	57.48	55.74	57.57	52.62	1.81	1.98	0.00	16.46*	0.87
Air Pollution		60.21	59.22	59.59	60.27	0.91	0.13	0.35	0.51	0.35
Alligator	pre	51.65	49.42	54.61	46.86	2.82	5.74*	0.51	16.15*	0.73
Water Pollution		59.91	58.59	59.07	59.15	1.55	0.21	0.62	0.00	0.00
DISCUSSION VARIABLES Gall-Crown Dis. Attitude Scale: Att. toward Thought Questions	pre	30.33	29.91	30.83	29.13	0.23	1.13	0.34	3.00	0.73
Attitude toward Discussion	pre	56.14	55.69	54.17	53.92	0.05	0.62	1.04	0.80	0.41
GENERAL TREATMENT VARIABLES Ecology Unit Opinions Scale: Attitude toward Peers		16.87	17.12	17.06	15.83	0.21	0.01	0.12	7.44*	0.97
Attitude toward Teacher		58.09	58.09	57.70	57.16	0.00	0.08	0.08	0.53	0.83
Attitude toward Curriculum		32.30	32.03	31.49	31.61	0.07	0.30	0.67	0.17	0.20
TREATMENT SPECIFIC VARIABLES Ecology Discussion Attitude Scale Att. toward Thought Questions		33.26	32.88	32.92		0.06	0.02	0.07		
Attitude toward Discussion	GDAS.pre.ds	59.67	59.39	60.23		0.02	0.13	0.00		
Ecology Art Project Scale: Attitude toward Art Projects					63.36					

*Significance at the .05 level. The .05 level for F values with 18 degrees of freedom is: $F_{1,18}=4.41$

[a]Prop. = Sum of squares for Treatments 1,2,3 vs 4 as a proportion of total treatment sum of squares

compared directly, since they incorporate different items and are of different lengths. However, a rough comparison of results can be made by computing the students' average rating per item, derived by dividing the group's total score by the number of items in the scale. The students in the discussion treatments completed the Ecology Discussion Attitude Scale. Their average rating per item on the Attitude toward Thought Questions subscale was 3.00, and on the Attitude toward Discussion subscale it was 3.15. The students in the art activity treatment completed the Ecology Art Project Scale, on which they gave an average rating per item of 3.33. Assuming equivalence of ratings in the two scales, it appears that students had slightly more positive attitudes toward the art activity treatment than their peers had toward the discussion treatments.

These results relate to the research objective of determining which student learning outcomes are affected by presence or absence of discussions. The results indicate that discussion of the type incorporated in the three discussion treatments in Study II may be slightly more effective than a competing no-discussion treatment in promoting positive student attitudes toward curriculum-related topics; however, students may perceive the experience of art activity slightly more favorably than they perceive discussion experiences.

Classroom, Teacher, and Square Effects

Even fewer of the analysis of variance effects for class, teacher, square, and treatment by square were statistically significant for the affective measures than for the achievement measures in Study II. The only significant effects were found for squares in the Water Pollution Scale and the Attitude toward Discussion Subscale of the Ecology

Discussion Attitude Scale. However, based on the number of analyses completed, these results can be accounted for by chance and contribute little to the interpretation of treatment effects.

STATUS VARIABLES

To test the possibility that differences obtained for post and delay variables were reflections of pre-existing differences in the sampled students rather than the result of experimental conditions, analyses of variance were performed on the total reading score and on the average number of lessons attended by students within a group. The results of these analyses were presented in Table 34. No statistically significant effects were observed for either variable. The omega squared values for analysis of variance effects were never greater than .02. Also, inspection of Table 35 indicates that the actual treatment means for these two variables fell within a relatively narrow range of values.

It can be concluded that neither general academic aptitude as measured by total reading ability nor differential absenteeism from instructional lessons were influential in producing differences in the study.

SUMMARY

The results of Study II can be summarized by referring to the two research objectives which guided the research.

1. The first objective was to determine which student learning outcomes were affected by variations in the percentage of higher cognitive questions in discussions. The results of the data analysis for Study II

indicated that differences in percentage of higher cognitive questions affected students' acquisition of knowledge and higher cognitive response ability, both oral and written. Further, low or high percentages of higher cognitive questions were more effective than moderate percentages of these questions in building students' recall of information about a specified curriculum.

Variations in percentage of higher cognitive questions in discussions appeared to have little effect upon students' attitudes toward the curriculum content or the learning situation.

2. The second research objective was to determine which student learning outcomes were affected by presence or absence of discussion. The results of Study II indicated that discussions were more effective than a competing instructional method (art activity) in facilitating knowledge acquisition and ability to respond to higher cognitive questions in oral and written form. They also may be slightly more effective in promoting positive student attitudes toward curriculum-related topics. However, the art activity method may be perceived as a slightly more positive instructional situation than the discussion method.

SECTION IV

DISCUSSION OF FINDINGS

CHAPTER SEVEN

DISCUSSION OF FINDINGS

Because both Study I and Study II investigated the effectiveness of teacher use of questioning techniques, the following discussion takes into consideration the results of both studies. In this way, the implications of the research findings in each study for the field of teaching and teacher training can be considered from a broader perspective.

The discussion covers six major topics. The first topic is a review of the research procedures and analysis of the advantages of these procedures compared to previous methodology in research on teaching. The second topic concerns the limitations of the research design in both studies. The third relates to the major research questions posed by the studies--the effects of questioning techniques upon students' achievement and attitudes. The fourth topic deals with secondary areas of interest such as comparison of students' oral and written responses, comparison of intentional and incidental learning effects, and possible competing hypotheses in the studies. The fifth topic concerns the findings as they relate to Minicourses 1 and 9, the teacher training products from which the teaching strategies that were investigated in the studies were derived (see Appendix A for the Minicourse objectives and skills). The final topic presents the implications of the findings for educational research in general, and for research on teaching in particular.

STRENGTHS OF RESEARCH DESIGN

Several recent reviews have criticized the technical quality of educational research and of research on teaching (e.g., Heath & Nielson, 1972 and 1974). Other reviews have suggested new approaches to research and how existing approaches could be applied more effectively (e.g., Cronbach, 1975). In both Study I and Study II, a concerted effort was made to reduce or eliminate eight research flaws identified in these reviews. These included one problem related to the assignment of students to treatments; one problem related to the appropriateness of student outcome measures; two problems related to "opportunity to learn"; two problems related to fidelity of treatment; and two problems related to statistical procedures. Consequently, the findings of Study I and Study II may be taken more seriously than those from the earlier studies and the implications for future research that are derived merit thoughtful consideration.

Assignment of Students

The majority of previous investigations of teacher questioning (reviewed by Rosenshine & Furst, 1971) assigned intact classrooms to treatments. Therefore, random assignment of students to treatment was limited by the extent to which a particular classroom represented a random sample of the student population. The validity of such an assumption is questionable. Based upon the classroom effects reported in Studies I and II, nonrandomness appears to be the more likely circumstance in intact classrooms.

The research designs for Study I and II solved the problem of specifying random assignment of students from each classroom to each treatment condition. This assignment procedure, coupled with the use in each study of twelve classrooms--two from each of six schools, increases the generalizability of the research results. It also increases the likelihood that the findings reflect treatment effects rather than pre-existing classroom differences.

Student Outcomes

Another research problem that received attention in Studies I and II was the extent to which the student outcomes measured in each study matched the instructional objectives of the treatment conditions. Several previous studies of the use of higher cognitive questions limited student outcome measures to paper-and-pencil fact recall tests (e.g., Wright & Nuthall, 1970). Similar tests were used in Study I and Study II, but they were supplemented by tests of students' higher cognitive response ability in both written and oral format and by tests of intentional (included in the treatment curriculum) and incidental (not included in the curriculum) information recall. These tests measured learning outcomes which the discussion treatments were specifically designed to affect.

Opportunity to Learn

Two conditions related to "opportunity to learn" were controlled more effectively in Studies I and II than in most previous research. Time on task and opportunity to learn the posttest content were equated across the different treatment conditions.

In Study I the filler activity and art activity treatments were designed to control and study the effects of time on task. In Study II the 25% and 50% HCQ treatments included filler activity so that time on task was controlled across these two treatments and the 75% HCQ treatment. The art activity treatment also had the same time specification as the HCQ treatments. It should be noted, however, that the filler activities used to control time on task in certain of the discussion treatments also should be considered as treatment variables inasmuch as they introduced additional learning experiences. Thus, they did not provide as pure a time control as might have been desired.

Opportunity to learn posttest content was controlled through (a) the specially-developed ecology curriculum, (b) the semi-programmed approach to the discussion treatments, and (c) the use of exemplary responses by the teacher if no student provided an adequate response during the discussion. As a result, much more is known about the actual instructional experience of students in Study I and Study II than in previous studies of teacher questioning. While careful control of opportunity to learn has many advantages, it also may have introduced a state of affairs that typically does not exist in the classroom--in fact, one can almost assume that such is the case. Such careful presentation of curricular content and sequencing of learning probably does not occur on a regular basis in most classroom discussions. The control of treatment conditions, therefore, may have created a learning situation in which the effects of the teaching skills, as they would be observed in regular discussions, were masked by the effects of the "ideal" instructional situation. This issue is of particular importance in Study I where use of probing and redirection showed no added effects upon student outcomes beyond the use of discussion, per se, in these carefully controlled treatments.

Treatment Conditions

In both Studies I and II treatments were defined and field-tested prior to initiation of the main research. During the studies, each treatment was monitored to assure maintenance of treatment conditions. The fidelity of treatment information presented earlier in this report indicates that the treatment conditions were maintained.

Teacher by treatment interactions represent a factor that may reduce the fidelity of the treatment and, therefore, obscure treatment effects. Studies I and II controlled for this problem in three ways. First, special ecology teachers were employed and trained to use the semi-programmed discussion treatments. Second, each teacher was randomly assigned to teach each treatment. Third, tape recordings of each teacher's conduct of two of the nine curriculum lessons were analyzed for each of the discussion treatments. Teacher use of treatment-specific and other strategies that the researchers considered important to the learning situation were scored.

The lack of teacher effects in Studies I and II indicates that these three measures controlled for teacher by treatment interactions. Therefore, it can be assumed that the treatment conditions in these studies were maintained at a much more exact level than in previous research. At the same time, the research was conducted in the regular school setting. As Snow (1974) observed, achieving treatment stability in a regular school setting is a matter of substantial importance. Studies I and II provide some insight into the strengths and weaknesses of one approach to the resolution of this problem.

Statistical Procedures

The final methodological problem to which Studies I and II responded concerns the critical assumptions underlying the statistical procedures used in analyses of data. Tests of the assumptions underlying adjustment of posttest scores were carried out in both of the studies. Whenever assumptions were not satisfied, the posttest scores were not adjusted.

As a result of the steps taken to resolve the eight problems cited above, the research in both Study I and Study II has made considerable progress in demonstrating that school-based research can be conducted with a high degree of experimental control. In effect, these studies used the school as a laboratory, maintaining the students in their natural setting (with the accompanying advantages) while imposing strict fidelity of treatment controls. Also, random assignment of students to treatment was achieved. Therefore, the findings of Study I and Study II warrant careful review both for their implications concerning the effectiveness of questioning techniques and for their implications concerning future research on teaching.

On the other hand, the use of a highly controlled experimental design limits the generalizability of the findings of the studies. The extent of these limitations is discussed in the following section.

LIMITATIONS OF RESEARCH DESIGN

Several of the limitations of research designs previously noted by Campbell & Stanley (1963) such as nonrandom assignment, differential mortality, maturation effects, and lack of fidelity of treatments were avoided in the two studies reported here. However, even though students were randomly assigned to treatments within the constraints of using intact classrooms as the sampling pool, there were substantial and systematic differences in the total reading scores of students assigned to the different treatments in Study I. Although these differences were not statistically significant, they complicate the interpretation of the Study I results.

Because of the sampling procedures used in the studies, contamination of treatments also is a potential problem. Even though random assignment of students from an intact classroom to all treatments strengthened the experiment in one respect, the presence of all the treatments in the classroom may have encouraged students in different treatments to discuss their training experiences and trade information and ideas about the curriculum with other students. Students were reminded several times during each study not to engage in this type of discussion. Informal observations were made to check this problem. These observations indicated that students followed the instructions, with the exception that students were aware that some of their classmates were participating in discussions and others were receiving written exercises and art activities. They generally were unaware of the specific questions and other activities which occurred in the different treatments. Therefore, it is unlikely that simple awareness of other treatments influenced the students' performance. It is also unlikely that students reviewed with each other the content of their discussions or written exercises. Thus, contamination of treatments is not a compelling explanation of observed treatment differences.

The use of dependent measures that appraised students' oral and written higher cognitive performance also added strength to the study. Yet, these measures pose several problems for interpretation. Except for the vocabulary and reading comprehension tests, these measures were specially designed. This development was necessary because there were no available measures which reflected the specific content taught in the experimental curriculum and because none existed which assessed the student outcomes hypothesized to be changed as a result of participation in the discussion treatments.

All of the measures were developed, pilot-tested, and revised to meet the standards of "good" tests, including high content validity, high internal consistency for the objective measures, and high inter-rater reliability for the subjective measures. In most cases the psychometric criteria were satisfied; the exceptions are the quality ratings for the question-generating measures where the interrater reliability was quite low and the absence of item statistics for the measures of higher cognitive response ability. This latter weakness reflects a general lack of sufficient research concerning the construction of test items which elicit open-form responses that are rated by trained scorers (see Coffman, 1971). Also, the construct validity of these higher cognitive measures needs further study. As a result, treatment differences on higher cognitive outcomes must be considered in the perspective of limitations in the instruments used to measure these outcomes.

While providing many important research controls, the two studies investigated a limited number of discussion parameters. Snow (1974) described the dangers in limiting the learning environment in order to gain control for research purposes. Possible limitations in the present research include the assessment of the effects of probing and redirection at one level of higher cognitive questioning (50 percent in Study I). This limitation becomes particularly significant given the findings of Study II. Furthermore, in both studies the treatments were limited to nine hours, using a single curriculum topic, and with only sixth-grade students. Variations in sequencing the lesson topics or in the manner in which they were presented, i.e., reading or viewing, were not investigated. In addition, the effects of discussion were studied in conjunction with a single viewing and/or reading of each curriculum lesson. The research did not attempt to study the possible facilitative effects of discussion in conjunction with other teaching strategies such as the use of advance organizers, role-playing, and review.

Perhaps the most significant limits on the generalizability of the findings are the fact that the experimental discussions were conducted in small groups of only six students and that the ecology teachers taught from semi-programmed discussion plans developed by the researchers which were delivered in rigidly defined ways. Therefore, the results probably cannot be used to judge the effectiveness or ineffectiveness of the use of discussion by teachers in regular classrooms.

Even with these limitations the findings have potent implications for future classroom practice and teacher training. Some of these implications will be discussed later.

One positive note concerning generalizability is that many features of Study I were repeated in Study II; namely, the same ecology teachers taught the lessons, students used the same curriculum, two of the treatments were identical across the two studies and most of the student outcome measures were repeated in both studies. The fact that the students in the school district involved in Study II were of a different ability level, as judged by scores on a reading achievement test, increases the generalizability of the findings to a more representative population of students. Also, the replication of certain results adds to generalizability.

To summarize, the studies were designed to achieve high internal validity at the cost of limiting their generalizability. The primary advantage of this emphasis is that the student effects found in Studies I and II can be attributed confidently to the experimental treatments; that is, variations in teacher behavior. In view of the design problems of previous research on teacher effects (Heath & Nielsen, 1973), this emphasis seems justified. Also, despite the use of novel, unstandardized measures of student achievement and attitudes, their use is justified by the fact that many of them were reactive to the treatments as theory would predict.

TREATMENT EFFECTS

Both Studies I and II focused upon research questions related to the effects of teachers' use of various types of questioning techniques upon students' achievement and attitudes. The specific characteristics of the treatments varied in order to study the effects of certain teaching skills (probing and redirection) and different percentages of higher cognitive questions asked by the teacher. The results of these studies were presented in Chapters Four and Six. Further discussion follows.

Achievement Outcomes

The overriding finding in both studies was that discussion was more effective in bringing about desired changes in student achievement than a no-discussion instructional experience. Planned comparisons of all discussion treatments with the art activity treatment in Study I revealed that the combined discussion treatments produced significantly higher scores on 12 of the 16 achievement variables. Nine such significant differences were found in Study II. The results suggest that discussion following initial viewing and/or reading of curriculum materials significantly improves:

- acquisition and retention of intentional and incidental information;
- ability to respond in oral and written form to curriculum-relevant higher cognitive questions, and to extend higher cognitive thinking into related content areas; and
- ability to generate curriculum-relevant questions that are pertinent, specific, and which contain requests for rationale.

These findings were based on a comparison of the discussion treatments with an art activity treatment in which the learning experiences following the viewing and/or reading of the curriculum materials were related to the curriculum content in only the broadest sense. Additional insight into the effects of discussion can be gained by comparing the Study I discussion treatments and the written exercise treatment.

In the written exercise treatment students responded to the same questions as the students who participated in the discussion treatments except that the questions were presented in written form. According to reports from the ecology teachers, the written exercise treatment was very difficult to maintain. Students often had to be persuaded to stay with the writing task. Various reward techniques had to be applied to encourage student motivation in this treatment (see page 22 for discussion of these techniques). Nonetheless, students in the written exercise treatment did as well as students in the various discussion treatments on all of the measures of information recall. Writing responses to questions appeared to develop knowledge acquisition as effectively as participation in a discussion of the same questions. On the other hand, students in the discussion treatments, particularly students in the probing and redirection treatment, gave better oral and written responses to curriculum-relevant higher cognitive questions; they also gave better written responses to questions requiring transfer to another curriculum topic.

The various discussion treatments in Study I made a significant difference only when contrasted with the written exercise treatment. They did not differ significantly from each other in student achievement outcomes.

Several plausible explanations for this finding can be offered. One explanation is linked to the assumption underlying teacher use of probing and redirection--that is, that probing and redirection provide a method of helping students arrive at a desired level of response to a question. In the discussion treatments in Study I these desired responses were achieved through two procedures: (a) teacher use of probing and redirection; and/or (b) by having the teacher provide the desired answers to both fact and higher cognitive questions when no students gave them. This latter situation, of course, occurred more frequently in the no probing and redirection and the filler activity treatments than in the probing and redirection treatment. In the written exercise treatment, on the other hand, students obtained input regarding desired responses only if they checked their answers against the exemplary answer sheets that were provided. Therefore, it appears that the effects of probing and redirection become apparent only when teacher use of probing and redirection is compared with situations in which student contact with teacher-provided exemplary responses varies in a more natural way than was permitted in the discussion treatments.

As long as students are exposed to exemplary responses, whether by the teacher (no probing and redirection and filler activity treatments) or by the student (probing and redirection treatment), higher cognitive skills are developed. Without such exposure, students acquire a lower level of skill.

The lack of significant differences in student acquisition of knowledge in the discussion treatments and the written exercise treatment further supports this interpretation of the findings. Since the information required to answer the fact and multi-fact questions asked in discussion or in written form can be found in the curriculum materials themselves, exemplary responses would not be as critical to student learning in these areas. Access to exemplary responses, no matter how provided, appears to have a significant effect only when the learning moves beyond the information contained in the curriculum itself. A secondary analysis of the Study I data is recommended to investigate more completely the effects of providing exemplary responses through both probing and redirection and teacher "telling." Such an analysis would provide a further test of the above hypothesis.

In Study II, the specific feature of the discussion situation that was investigated was the effect of the percentage of higher cognitive questions asked by the teacher during the discussion. Using the semi-programmed materials, the ecology teachers asked 25 percent, 50 percent, or 75 percent higher cognitive questions depending upon the treatment being conducted. The effects of these treatments were compared with one another and with an art activity treatment. As in Study I, filler activities were used to equate the time of the three discussion treatments, and teachers provided exemplary responses to questions if students failed to provide the desired response.

The most impressive finding from this study was the unexpected difference in learning outcomes between students in the 50 percent HCQ treatments and students in the 25 percent HCQ and 75 percent HCQ treatments. The drop in achievement outcomes in the factual areas for the 50 percent HCQ treatment was not anticipated. To aid in interpreting these results, additional analyses were conducted by Dr. Richard Snow, Stanford University. These are reported in Extended Analysis of Two Experiments on Teaching (Snow, et al., 1976). One plausible explanation is that the instructional purpose of the 25 percent and 75 percent HCQ discussions may have been more obvious to the students and thus facilitated their learning. In the 50 percent treatment, the even mixture of fact and higher cognitive questions and the transition from one type to another during the discussion may have been confusing to students.

The V-shaped findings in Study II also have implications for interpreting the results of Study I, since the Study I discussions were built around the semi-programmed format of the 50 percent HCQ treatment. Unfortunately, the possible interactive effects between this treatment condition and probing and redirection on Study I findings cannot be determined from the available data. Additional research is necessary utilizing the 25 percent HCQ and 75 percent HCQ semi-programmed materials as a basis for clarifying the effects of probing and redirection.

In comparisons of the findings of Study I and Study II, another issue that merits further inquiry was identified. This is the relationship that may exist between students' reading ability, the context of the discussion, and achievement outcomes.

Although achievement scores were adjusted to incorporate differences in students' reading ability within each study, the average reading ability of the students in Study II was somewhat higher than that of the students in Study I. The average score for Study I students on the CTBS, Form Q, Level 2, was 55.27 (grade level equivalent of 5.2); in Study II the average score on the CTBS, Form Q, Level 2, was 63.72 (grade level equivalent of 6.2).

It also appears that the significant differences between the combined discussion treatments and the no-discussion art activity treatment follow different patterns in the two studies. In Study I, nine of the 12 significant differences were on measures of higher cognitive outcomes. In contrast, in Study II, only four of the nine significant differences were on measures of higher cognitive outcomes. The larger number of significant differences in Study I than in Study II suggests that discussions contribute more to skill development, particularly higher cognitive development, for students with lower reading abilities, than for students with higher reading abilities.

In summary, the combined results of Studies I and II with respect to student achievement outcomes indicate that the total context of the discussion including the type of students who are involved, the overall structure and purpose of the discussion, and the total set of teaching strategies employed may be more important to learning than specific differences in teacher use of isolated skills such as probing, redirection, and number of higher cognitive questions asked.

Based on this finding, we suggest that further study of isolated teaching skills without regard for the students who are involved in the teaching-learning situation and the purpose of the instruction does not appear to be warranted. Training in use of teaching skills separate from the larger context of instruction also needs to be re-examined. Merely counting how many times a teaching skill is used is insufficient evidence to determine that effective teaching has occurred.

Attitude Outcomes

In both Study I and Study II, students' attitudes toward curriculum-related topics, toward discussions in general, and toward treatment-specific learning experiences were measured.

The results were similar in both studies. Neither the format of the discussions nor the presence or absence of discussions appear to affect student attitudes. The few significant differences that did occur probably should be attributed to chance given the larger number of comparisons that were made in each study. In Study I, the only attitudinal measure which differentiated significantly between the discussion treatments and the art activity treatment was the Alligator subscale of the Word Association Scale. However, each of the discussion means was higher than the art activity mean for five of the six subscales included in this measure. In Study II, the results for the attitude scales indicate that the discussion groups expressed significantly more positive attitudes on the Alligator and Wolf subscales of the Word Association Scale than did the art activity groups. The art activity groups also had the lowest mean on two other of the six subscales. These findings replicate the Study I results and provide further support for the generalization that students' attitudes toward discussion are positive.

In retrospect, this finding is not unexpected. All of the Study I and II treatments were an unusual experience for the students. Regardless of the treatment to which a student was assigned, he had an opportunity to engage in a learning activity that differed from his usual classroom routine. Since the treatments lasted for only two weeks, the change in routine alone probably would contribute to a positive attitude for all students at the end of the two-week period. Treatments of longer duration appear to be necessary in order to reveal differences in students' attitudes, if such differences do exist.

SECONDARY QUESTIONS

The designs for Studies I and II permitted the investigation of three secondary questions. The first relates to differences in students' higher cognitive outcomes based upon oral and written measures; the second relates to intentional versus incidental learning; the third to possible competing hypotheses.

Oral Versus Written Measures of Higher Cognitive Response in Studies I and II

One of the major assumptions underlying the design of the dependent measures of achievement in the two studies was that the effects of discussions would be assessed best by using student achievement measures that closely paralleled the oral response patterns elicited by the discussion treatments Therefore, an Oral Test was designed to meet these specifications: the questions were asked orally, students gave oral responses, and the responses were open rather than restricting the answer to multiple-choice discriminations.

An assessment of the sensitivity of the Oral Test may be made by comparing students' outcomes on this test with their outcomes on the Essay Test. A reasonable hypothesis is that the discussion treatment groups will make greater gains on the Oral Test than on the Essay Test. Also, one can hypothesize that the written exercise treatment group of Study I will make greater gains on the Essay Test than on the Oral Test, since the former measure is more consistent with the response-modality which dominated the written exercise treatment.

Since the Oral and Essay Tests contained different numbers of items, students' outcomes on the two tests were equated by computing average scores per item. The same rating procedures were used on both tests. Therefore, similar levels of performance would be expected to result in similar average scores per item on both tests. Two scores were derived for each item:

- a content score--the number of predictions, solutions, supported opinions, explanations, and inference given by the student.
- a logical extension score--the number of "because" and "if-then" relationships supplied by the student.

The first analysis tested the hypothesis that discussion treatment groups made greater gains on the Oral Test than on the Essay Test. The average scores per item for the combined Study I discussion treatment groups were 1.01, and 1.45 on the pretest and posttest administrations of the Oral Test Content Scale, respectively. In contrast, their average scores per item on the Essay Test Content Scale were .77 on the pretest administration and .88 on the posttest administration. The Logical Extension Scales for the two tests showed similar differences. The combined discussion treatment groups increased their average score per item on the Oral Test Logical Extension Scale from .30 on the pretreatment administration to .55 on the posttreatment administration. In contrast, their scores on the Essay Test Logical Extension Scale barely changed from .09 to .10.

The same pattern of results is found in Study II. For the combined discussion treatment groups in this study, the average score per item on the Content cale of the Oral Test increased from 1.01 to 1.45, whereas the increase on the same scale in the Essay Test was only from .87 to .99. Similarly, the combined discussion groups' increase on the Oral Test Logical Extension Scale was from .39 to .61, whereas the change on the Essay Test Logical Extension Scale was minimal, from .17 to .18.

These findings lend support for the hypothesis that discussions have more effect on students' ability to respond to higher cognitive questions in oral form than on their ability to respond to similar questions in paper-and-pencil form. However, the data presented here do not provide a rigorous test of the hypothesis. For example, the data analysis assumes that the test items in the Oral Test and Essay Test are parallel in form and difficulty; however, the soundness of this assumption could not be checked empirically using the available data. Moreover, there is evidence that rater awareness of the time of administration of the Oral Tests may have influenced their scoring of students' performance. The limits of the generalization require further testing. For example, there may be a point in cognitive development when students' writing ability may come to equal or even exceed their ability to respond orally.

The second hypothesis of interest in comparing the use of oral versus written achievement measures is whether students in the written exercise treatment in Study I made greater gains on the Essay Test than on the Oral Test.

Again, using average scores per item, the students in the written exercise treatment scored an average of 1.16 per item on the pretreatment administration of the Oral Test Content Scale and an average of 1.27 per item on the posttreatment administration. In contrast, their average score per item on the Essay Test Content Scale declined slightly, from .84 to .82. Their performance on the Oral Test Logical Extension Scale increased from an average score per item of .38 on the pretreatment administration to .47 on the posttreatment administration. Again, a decline was observed on the same scale in the Essay Test, from an average score per item of .12 on the pretreatment administration to an average score per item of .08 on the posttreatment administration.

These results do not support the hypothesis of differential modality effects for the written exercise treatment. Instead, they indicate that practice in completing written exercises did not positively improve learning measures of the same modality as the treatment. However, students' performance on the pretreatment and posttreatment administrations of the Oral Test indicates that they were making gains in higher cognitive processing abilities. Thus, it appears that the written exercise treatment group learned from the written exercise teaching strategy, but were unable to express their learning in written form.

These results argue for the need to use oral response measures when measuring sixth-grade students' higher cognitive ability regardless of the treatment conditions being studied. Apparently, requiring students' to write their responses limits and/or inhibits the number and type of higher cognitive relationships they express.

The implications of this finding are considerable both for future research and for interpretation of past research. Upper elementary students' higher cognitive responses have been measured in oral form in few if any other research studies to date. Lack of such data may have imposed severe limitations on the findings of those studies. The importance of including such measures in future studies would serve two purposes: the further testing of the hypotheses raised by the current research as well as "covering the bases" in studying the effects of other instructional treatments.

Intentional versus Incidental Knowledge Acquisition in Studies I and II

For purposes of this discussion, whether a particular measure reflects intentional or incidental learning can be determined by referring to the treatment conditions imposed in the two studies. If the knowledge required to respond to an item on the Information Test was covered in the semi-programmed discussions, the item was considered to be a measure of "intentional" knowledge acquisition. However, if the knowledge required to respond to the item was contained in the ecology curriculum but not in the semi-programmed discussions, the item was considered to be a measure of "incidental" knowledge acquisition.

It should be noted that inquiry into this aspect of the research was made possible through the careful definition and implementation of the ecology curriculum and the various treatments. Only when treatments are well delimited can such hypotheses be investigated.

In Studies I and II it is reasonable to hypothesize that students would recall curriculum information which was covered in the discussions better than they would recall curriculum information which was not discussed in this way. This hypothesis can be tested by comparing the discussion treatment groups' performance on the intentional scale of the Information Test with their performance on the incidental scale of the same test. Since the intentional and incidental scales are of different lengths and were not constructed by drawing items randomly from an item pool, comparison of scores from the two scales needs to be made cautiously.

To equate scale length, an average score per item was computed; that is, a treatment group's mean score on the scale was divided by the number of items included in the scale. A rough index of the equivalence of item difficulty in the intentional and incidental scales was obtained by comparing the art activity treatment groups' performance on these scales. The two scales should have approximately equal mean item scores since they are equally "incidental" for this group.*

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* The items in the intentional scales in the two studies are "intentional" only for the discussion treatment groups.

The average scores per item for the combined discussion treatments in Study I was .61 for the posttreatment Intentional Scale I and .44 for the posttreatment Incidental Scale I. As predicted, discussion appears to facilitate the acquisition of intentional facts more than it facilitated the acquisition of incidental facts. However, the average scores per item for art activity treatment I were .43 on the posttreatment Intentional Scale I and .35 for the posttreatment Incidental Scale I. This difference suggests that the intentional scale was slightly less difficult than the incidental scale. The hypothesis that discussion treatments fostered the learning of intentional scale items more than incidental scale items is still tenable, though, since the difference between the intentional scale and incidental scale scores for the art activity is small and does not account for all the difference observed between the intentional and incidental scales for the discussion treatment groups.

A similar analysis of the delayed administration scores on the intentional and incidental scales provides further support of the "intentional learning" hypothesis. The average scores per item for the combined discussion treatment groups in Study I were .53 on the intentional scale and .41 on the incidental scale. The corresponding average scores per item for the Study I art activity treatment group were .38 and .35, respectively. Even taking into account the possibility of slightly easier items on the intentional scale than on the incidental scale, the discussion treatment groups performed better on the intentional scale than they did on the incidental scale.

Study II used different intentional and incidental scales, but the items were derived from the same item pool of 27 items on the Information

Test used in Study I. Again, average scores per item were calculated since the two scales included different numbers of items. The average scores per item for the combined discussion treatment groups of Study II were .77 on the post administration of the intentional scale and .56 on the post administration of the incidental scales. The corresponding average scores per item for the Study II art activity treatment group were .66 and .50, respectively.

This analysis suggests that the intentional scale contained substantially easier items than the incidental scale. In Study II, the magnitude of this difference is slightly less than the difference between the intentional and incidental scales for the discussion treatment groups, suggesting that, in this study, differences between the intentional and incidental average item scores for the discussion groups were probably due to the differences in item difficulty for the two scales rather than real differences in intentional versus incidental learning.

The results basically are the same for the analysis of the delayed administration of these scales in Study II. The average scores per item for the combined discussion treatment groups were .72 and .52 on the delayed administration of the intentional and incidental scales, respectively; the corresponding scores for the art activity treatment group were .60 and .47, respectively. While there appears to be a slight advantage for the combined discussion groups on the intentional scale, this difference is probably due to differences in item difficulty rather than differences in intentional versus incidental learning.

Another test of the hypothesis that covering specific facts in a discussion promotes later recall of the same facts can be made by examining the data for the 25 percent Intentional Scale. This scale includes items which were intentional for the 25 percent higher cognitive questions treatment in Study II, but incidental for the other discussion treatments in the study and for the art activity treatment. As predicted, the average score per item on the 25 percent Intentional Scale for the 25 percent treatment groups was substantially higher (.45) than the average scores per item for the other treatments, which differed little among themselves (range = .36 to .37).

It also is of interest to determine whether inserting fact questions in written exercises, as in the written exercise treatment of Study I, affects intentional and incidental learning in the same way. The average scores per item for this group on the intentional and incidental scales were .62 and .46, respectively. The corresponding scores on the delayed administration of the same scales were .52 and .42, respectively. These scores are similar to those reported above for the combined discussion treatment groups in Study I, and similar interpretations apply.

It must be emphasized that the analyses presented here lack the rigor needed to provide a definitive test of the "intentional learning" hypothesis. They are exploratory in nature. However, they provide some support for the hypothesis that if a teacher wants students to learn a specific set of facts in a curriculum, an effective approach is to cover these facts in an oral discussion or written exercise involving question-and-answer.

Competing Hypotheses

Three possible competing hypotheses to explain treatment group differences are of interest in interpreting the outcome of Studies I and II.

These are the effects of the status variables of initial student ability, exposure to treatments, and the effects of the individual ecology teachers.

Measures of initial ability were obtained from student reading scores on the state-administered Comprehensive Tests of Basic Skills. Differences in reading ability between the Study I and Study II students have already been discussed with respect to their possible role in explaining differences in findings between the two studies. In this section of the discussion, therefore, attention will be given only to possible effects of initial ability within each study separately.

To check on the equivalence of ability among treatment groups within each study, an analysis of variance was performed on total reading scores. As discussed in Chapter Four, in Study I there were no statistically significant differences in total reading scores attributable to treatments, teachers, classes, squares, or treatment by square interactions. It should be noted, however, that the average total reading scores for each treatment were ordered in the direction of *a priori* hypotheses about the probable effects of each discussion treatment: that is, the students in the probing and redirection treatment had the highest mean total reading score; the students in the no probing and redirection, filler activity, and art activity treatments had slightly lower mean scores in that order.

In Study II no statistical differences in total reading scores were identified for student classification by treatment, class, teacher, square, or treatment by square. Moreover, the absolute differences between treatment group means on total reading score were very small.

It appears, therefore, that within each study, differences between treatments in student outcomes should not be attributed to differences in reading ability of the groups. Moreover, since the dependent measures in both studies were residualized on total reading scores whenever assumptions underlying this procedure were satisfied, any treatment differences that were found may be attributed to treatment effects rather than to the effect of initial ability.

Students' exposure to treatments was measured by the number of sessions attended. Analyses of variance, reported in Chapters Four and Six, showed no significant differences among treatment groups on this variable in either study. Also, the correlations between sessions attended and the other dependent variables were low. In Study I, the largest correlation was -.27, with only five exceeding .10 in absolute value. In Study II, the largest correlation was .12, with only three exceeding .10. Thus, differences in exposure to treatment are not related to observed variability in student learning.

In both studies, teachers were trained to implement a prescribed curriculum and to conform to scripted variations in teaching behavior. The observational data concerning fidelity of treatment implementation (see Tables 2, 3, 23, 24) show that it was possible to train teachers to conform to precise standards of teaching performance. The results of the analyses of variance for teacher effects are also impressive. These analyses, presented in Chapters Four and Six, show that teacher effects account for very little of the variance in student performance on the dependent measures. Differences attributable to teacher effects reached statistical significance for only three of the 64 dependent variables measured across both studies.

This number is exactly the number of significant differences at the .05 level that would be expected by chance.

The method of studying teacher effectiveness experimentally by "programming" the teachers to vary their behavior has been used previously in research. However, the studies reported here represent one of the most rigorous uses of the method yet attempted. Most noteworthy is the fact that in Studies I and II the same teacher was trained to implement several different teaching strategies. The advantage of this method is that it controls effects attributable to a single teacher by allowing them to be systematically distributed across all treatments. A much larger sample of teachers would be required to achieve the same control if the researcher wished to randomly assign separate groups of teachers to be trained to implement each strategy. It should be emphasized, however, that the ecology teachers used in the two studies were preselected for their interpersonal skills and their interest in educational research. The effectiveness of the experimental methods used in these studies may not hold for all teachers and all teaching strategies.

IMPLICATIONS FOR USE OF MINICOURSES 1 AND 9

The teaching skills that were investigated in Studies I and II were taken from the skills included in Minicourse 1, Effective Questioning - Elementary Level, and Minicourse 9, Higher Cognitive Questioning.

At the time that the Minicourses were developed and field tested, the effect of training upon teacher behavior was studied. Comparison of these findings with those from the present research provides several important guidelines for future use of the courses.

Since teacher use of higher cognitive questions was included in both Minicourses, results from the main field tests of the courses provide an indication of teacher use of this skill within a more natural classroom environment. Because the lessons used in the main field tests were markedly different from the semi-programmed discussion materials used in Studies I and II, the main field test findings cannot be compared directly with the treatment conditions in the present research. However, the findings can offer some guidelines for future teacher training efforts.

The Minicourse 1 main field test (Borg, et al., 1969) indicated that before training teachers used an average of [illegible]8 percent higher cognitive questions; immediately after training they used 50 percent higher cognitive questions; three years later they used 51 percent. In the Minicourse 9 main field test (Gall, Dunning, Galassi, & [illegible]anks, 1970) fourth through sixth-grade teachers used an average of 4[illegible] percent higher cognitive questions before training and 67 percent after training. The control group teachers in this field test used 52.2 percent higher cognitive questions in the pre-training lesson and 45.3 percent in the post-training lesson.

Since Study II results suggest that the 50 percent higher cognitive questions treatment was, in some respects, the least effective treatment, the field test findings for Minicourses 1 and 9 appear to present some problems. After training, the Minicourse 1 teachers performance level reached the level of the least effective treatment--50 percent higher cognitive questions. Minicourse 9 teachers increased their use of higher cognitive questions beyond the 50 percent level but not to the 75 percent level. Training based on either of the Minicourses, therefore, may need to be redesigned. Teachers may need to increase the number of practice microteach lessons they conduct in order to attain flexibility in the use of higher cognitive questions and to acquire the ability to plan and conduct lessons containing 25 and 75 percent higher cognitive questions as well as 50 percent.

Furthermore, since the present research suggests that a teacher's use of higher cognitive questions may not, in and of itself, lead to improved performance for all students, trainers using Minicourses 1 and 9 should give special attention to the context of the instructional situation. In particular, attention should be given to the structure of the discussion in which the questions are asked. The more effective treatments in Study II --25 percent HCQ and 75 percent HCQ--had an obvious purpose and structure. The strategy of constructing and implementing "programmed" discussions such as those used in Studies I and II, that is, discussions containing fact and higher cognitive questions relevant to the curriculum objectives and presented in a purposeful sequence, probably should be added to the Minicourse training.

IMPLICATIONS FOR FUTURE RESEARCH

The research reported in Studies I and II has several important implications for educational research.

The most important implication has to do with the dimensions of the teaching-learning situation that should be studied. Much of previous research on teaching has focused upon teacher use of specific skills with little attention to the entire teaching-learning situation. In the present research, the total context of the discussion treatment (i.e., the sequence in which the questions were asked as well as the questions themselves and the entire set of behaviors used by the teacher rather than just the use of probing and redirection) had to be considered in order to explain the research results. It appears that future research on teaching would benefit by similar concern for the total instructional context rather than for a few specific teaching skills.

In order to expand the dimensions of the teaching-learning situation to be studied, the curriculum, the structure of each lesson, and the specified aspects of teaching must be carefully controlled. The semi-programmed approach applied in Studies I and II is one method for controlling the "treatment." Other approaches need to be developed and tried. The semi-programmed approach, while controlling treatment conditions, severely limits the generalizability of the research findings to teaching in general. Approaches that accommodate more "natural" variation in teaching are needed.

The results of Study I suggest that multiple teaching strategies--teacher use of probing and redirection and/or teacher provision of exemplary responses--may result in similar outcomes for students. To our knowledge, no studies have been conducted that seek to determine what, if any, options in the use of teaching skills are available to teachers. The work of Brophy and Good (1972) and Brophy and Evertson (1974) investigated effective teaching in urban and suburban settings. This research identified different teaching strategies as effective in these sites. Other research has searched for relationships between certain teaching skills and student outcomes. To our knowledge, however, to date, no research has attempted to test experimentally (intentionally) whether two or more teaching strategies are equally effective in achieving the same student outcomes with similar students and/or different students. Given that teachers have different teaching styles, identifying such alternatives--if they exist as suggested in Study I--has important implications for both teaching and teacher training.

The comparison of the results of Study I and II supports the theory that students with different entry level abilities perform better in one treatment than another. The comparison of the two studies also suggests that students with different entry levels may learn different things as a result of the same treatment. The reanalysis to be reported by Snow and his colleagues will provide further insight into this area of aptitude-treatment interactions. The research reported here supports continued emphasis in this area of research on teaching and learning. It stresses the importance of measuring a variety of student entry skills.

In both Studies I and II, considerable attention was given to matching student outcome measures with the objectives of the treatment conditions. This, in turn, required the development of several new measures of students' cognitive abilities. These included measures of students' ability to express the results of their thinking in oral form. The results of the studies, particularly the large number of treatment effects for the higher cognitive measures in Study I, suggest that the measures were important to the research. Future research concerned with student learning outcomes should no longer limit measurement of the outcomes to fact-recall paper-and-pencil tests. Much remains to be done to establish the validity and reliability of both written and oral measures of higher cognitive performance, but their potential for increasing our understanding of the effects of different instructional treatments appears clear from the findings of Study I and Study II.

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APPENDIX A

Objectives and Skills of
Minicourse 1 and Minicourse 9

TABLE A-1

Objectives and Skills of Minicourse 1, Effective Questioning -- Elementary Level

INSTRUCTIONAL SEQUENCE 1

Objective	To change teacher behavior (teaching techniques and practices) in order to increase pupil readiness to respond to discussion questions.
Skills Covered	Asking question, pausing three to five seconds, then calling on pupil. Dealing with incorrect answers in an accepting, nonpunitive manner. Calling on both volunteers and nonvolunteers in order to keep all pupils alert and to distribute participation.

INSTRUCTIONAL SEQUENCE 2

Objective	To improve teacher skills so as to decrease the amount of teacher participation and increase the amount of pupil participation.
Skills Covered	Redirecting the same question to several pupils. Framing questions that call for longer pupil responses. 1. Asking for sets or groups of related facts when formulating information-level questions. 2. Avoiding Yes or No replies. Framing questions that require the pupil to use higher cognitive processes.

INSTRUCTIONAL SEQUENCE 3

Objective	To increase teacher use of probing techniques in order to guide the pupil to more complete and thoughtful responses.
Skills Covered	Prompting. Seeking further clarification and pupil insight. Refocusing the pupil's response.

INSTRUCTIONAL SEQUENCE 4

Objective	To reduce teacher behavior that interferes with the flow of the discussion.
Skills Covered	Observing the following rules: 1. Teacher should not repeat his own questions. 2. Teacher should not answer his own questions. 3. Teacher should not repeat pupil answers.

TABLE A-2

Objectives and Skills of Minicourse 9, Higher Cognitive Questioning

Preliminary Lesson

Objective	To introduce the first three question types in Bloom's taxonomy of cognitive objectives.
Skills Covered	Writing and classifying knowledge, comprehension, and application questions.

LESSON 1

Objective	To develop your skill in helping students improve the quality of their answers to higher cognitive questions.
Skills Covered	Using performance criteria in order to judge student responses. Using probing questions to help students improve their answers.

LESSON 2

Objective	To increase your use of analysis questions.
Skills Covered	Asking three types of analysis questions: 1. Having students think of motives or causes to explain observed events. 2. Having students make inferences, interpretations, or generalizations. 3. Having students find evidence to support generalizations, interpretations, or conclusions.

LESSON 3

Objective	To increase your use of synthesis questions.
Skills Covered	Asking three types of synthesis questions: 1. Having students make predictions. 2. Having students solve problems. 3. Having students produce original communications.

LESSON 4

Objective	To increase your use of evaluation questions
Skills Covered	Asking four types of evaluation questions: 1. Having students give their opinions about issues. 2. Having students judge the validity of ideas. 3. Having students judge the merit of problem-solutions. 4. Having students judge the quality of art and other products.

APPENDIX B

Psychometric Statistics for Study I Measures

TABLE B-1

Study I

Correlation Matrix of Ecology Information Subtests

VARIABLE	1	2	3	4	5	6	7	8	9
1. Total Scale (Pre)		.67	.88	.56	.48	.54	.48	.40	.47
2. Intentional Scale I (Pre)			.24	.37	.37	.31	.31	.32	.26
3. Incidental Scale I (Pre)				.51	.38	.51	.44	.32	.45
4. Total Scale I (Post)					.87	.93	.80	.69	.76
5. Intentional Scale I (Post)						.63	.71	.71	.60
6. Incidental Scale I (Post)							.74	.57	.75
7. Total Scale (Delay)								.88	.93
8. Intentional Scale I (Delay)									.64
9. Incidental Scale I (Delay)									

TABLE B-2

Study I
Alpha Coefficients and Standard Errors of Measurement of Ecology Information Subtests

PRETEST

Treatment	Sample Size	Total Scale (27 Items)		Intentional Scale I (10 Items)		Incidental Scale I (17 Items)	
		Alpha Coeff	Sem	α	Sem	α	Sem
Probing & Redirection	71	0.44	2.28	0.03	1.33	0.39	1.85
No Probing & Redirection	70	0.36	2.35	0.00	1.33	0.30	1.83
Filler Activity	70	0.39	2.23	0.35	1.29	0.26	1.81
Art Activity I	63	0.42	2.28	0.11	1.36	0.28	1.83
Written Exercises	50	0.39	2.25	0.37	1.27	0.30	1.84

POSTTEST

Treatment	Sample Size	Total Scale (27 Items)		Intentional Scale I (10 Items)		Incidental Scale I (17 Items)	
		Alpha Coeff	Sem	α	Sem	α	Sem
Probing & Redirection	71	0.85	2.25	0.76	1.27	0.75	1.84
No Probing & Redirection	67	0.84	2.28	0.74	1.32	0.74	1.85
Filler Activity	69	0.79	2.30	0.69	1.33	0.67	1.85
Art Activity I	64	0.67	2.34	0.44	1.40	0.60	1.86
Written Exercises	50	0.75	2.34	0.60	1.36	0.63	1.89

DELAYED TEST

Treatment	Sample Size	Total Scale (27 Items)		Intentional Scale I (10 Items)		Incidental Scale I (17 Items)	
		Alpha Coeff.	Sem	α	Sem	α	Sem
Probing & Redirection	67	0.84	2.29	0.74	1.32	0.75	1.84
No Probing and Redirection	65	0.82	2.33	0.77	1.33	0.61	1.91
Filler Activity	65	0.83	2.28	0.69	1.34	0.69	1.83
Art Activity I	64	0.72	2.29	0.51	1.39	0.66	1.80
Written Exercises	50	0.82	2.29	0.67	1.36	0.74	1.84

TABLE B-3

Study I
Correlation Matrix of
Oral Test Variables

VARIABLES	1	2	3	4
1. Content Scale (Pre)		.61	.59	.48
2. Logical Extension Scale (Pre)			.44	.51
3. Content Scale (Post)				.66
4. Logical Extension Scale (Post)				

TABLE B-4

Study I
Correlation Matrix of
Essay Test Variables

VARIABLES	1	2	3	4
1. Content Scale (Pre)		.62	.71	.44
2. Logical Extension Scale (Pre)			.42	.39
3. Content Scale (Post)				.57
4. Logical Extension Scale (Post)				

TABLE B-5

Study I

Correlation Matrix of Question-Generating Test Variables (Paper and Pencil Measure)

VARIABLES	1	2	3	4	5	6	7	8	9	10
1. Nonpertinent Questions (Pre)		-.18	-.11	-.05	-.51	.53	-.08	-.07	-.12	-.18
2. Pertinent Questions (Pre)			.37	.29	.12	-.08	.61	.21	.17	.23
3. Specificity (Pre)				-.01	.15	.00	.15	.39	-.01	.21
4. Requests for Rationale (Pre)					.12	.01	.15	.05	.40	.09
5. Quality Rating (Pre)						-.27	.02	.04	.09	.42
6. Nonpertinent Questions (Post)							-.15	-.05	-.10	-.26
7. Pertinent Questions (Post)								.42	.28	.24
8. Specificity (Post)									.19	.28
9. Requests for Rationale (Post)										.15
10. Quality Rating (Post)										

TABLE B-6

Study I
Intraclass Correlation Coefficients for Question-Generating Test Variables (Paper and Pencil Measure)

VARIABLE	Pretest	Posttest
Nonpertinent Questions	.84	.55
Pertinent Questions	.97	.95
Specific Questions	.83	.87
Requests for Rationale	.90	.94
Quality Rating	.29	.25

Table B-7

Study I
Correlation Matrix of Question-Generating Test Variables (Oral Measure)

VARIABLES	1	2	3	4	5	6
1. Nonpertinent Questions (Pre)		-.09	-.14	.50	.07	-.04
2. Pertinent Questions (Pre)			.65	.04	.46	.32
3. Quality Rating (Pre)				-.01	.45	.43
4. Nonpertinent Questions (Post)					-.03	-.10
5. Pertinent Questions (Post)						.57
6. Quality Rating (Post)						-

TABLE B-8

Study I

Correlation Matrix of Word Association Sutscales

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12
1. Balance of Nature (Pre)	-	.28	.89	.08	.16	.11	.30	.20	.07	.08	.10	.10
2. Ecology (Pre)			.20	.20	.24	.17	.30	.37	.17	.19	.18	.15
3. Alligator (Pre)				.02	.58	.04	.16	.17	.46	.03	.38	.03
4. Air Pollution (Pre)					.06	.66	.16	.24	.19	.30	.19	.32
5. Wolf (Pre)						.03	.14	.16	.40	.09	.52	.09
6. Water Pollution (Pre)							.27	.23	.18	.40	.23	.49
7. Balance of Nature (Post)								.43	.24	.23	.34	.21
8. Ecology (Post)									.25	.33	.30	.28
9. Alligator (Post)										.13	.65	.11
10. Air Pollution (Post)											.21	.79
11. Wolf (Post)												.21
12. Water Pollution (Post)												-

TABLE B-9

Study I
Alpha Coefficients and Standard Errors of Measurement of Word Association Subscales

PRETEST

TREATMENT	SAMPLE SIZE	BALANCE OF NATURE		ECOLOGY		ALLIGATORS		AIR POLLUTION		WOLF		WATER POLLUTION	
		Alpha Coeff	Sem	α	Sem	α	Sem	α	Sem	α	Sem	α	Sem
Probing & Redirection	70	0.70	4.26	0.80	4.41	0.81	4.89	0.69	5.01	0.75	4.74	0.67	5.01
No Probing & Redirection	68	0.78	4.14	0.87	4.38	0.79	5.21	0.60	4.51	0.85	4.53	0.65	4.96
Filler Activity	68	0.76	4.52	0.83	4.21	0.85	4.89	0.61	4.28	0.85	4.78	0.52	4.60
Art Activity I	60	0.83	4.86	0.89	4.83	0.78	5.58	0.69	5.28	0.80	5.24	0.69	5.21
Written Exercise	50	0.74	4.72	0.91	4.57	0.75	5.09	0.47	4.58	0.82	4.59	0.62	4.60

POSTTEST

TREATMENT	SAMPLE SIZE	BALANCE OF NATURE		ECOLOGY		ALLIGATORS		AIR POLLUTION		WOLF		WATER POLLUTION	
		Alpha Coeff	Sem	α	Sem	α	Sem	α	Sem	α	Sem	α	Sem
Probing & Redirection	66	0.85	4.10	0.89	4.02	0.78	4.55	0.31	4.46	0.80	4.08	0.45	4.46
No Probing & Redirection	64	0.87	4.12	0.91	3.72	0.82	4.91	0.51	4.19	0.89	4.15	0.56	4.19
Filler Activity	64	0.88	4.05	0.87	3.63	0.89	4.49	0.70	4.30	0.86	4.57	0.72	4.28
Art Activity I	59	0.91	3.39	0.88	3.87	0.84	5.24	0.49	4.54	0.88	4.45	0.60	4.82
Written Exercise	45	0.82	4.49	0.96	2.80	0.72	4.47	0.64	4.61	0.84	4.13	0.55	4.49

TABLE B-10

Study I
Correlation Matrix of Gall-Crown Discussion Attitude Subscales

VARIABLES	1	2	3	4
1. Attitude toward Thought Questions (Pre)		.69	.55	.44
2. Attitude toward Discussions (Pre)			.52	.60
3. Attitude toward Thought Questions (Delay)				.60
4. Attitude toward Discussions (Delay)				-

TABLE B-11

Study I
Alpha Coefficients and Standard Error of Measurement of Gall-Crown Discussion Attitude Subscales

PRETEST

TREATMENT	SAMPLE SIZE	ATTITUDE TOWARD THOUGHT QUESTION (11 items)		ATTITUDE TOWARD DISCUSSION (19 items)	
		Alpha Coeff.	Sem	α	Sem
Probing and Redirection	71	0.72	2.68	0.85	3.23
No Probing and Redirection	69	0.70	2.75	0.86	3.39
Filler Activity	69	0.73	2.74	0.81	3.36
Art Activity I	64	0.74	2.85	0.80	3.65
Written Exercise	51	0.80	2.68	0.84	3.35

DELAYED TEST

TREATMENT	SAMPLE SIZE	ATTITUDE TOWARD THOUGHT QUESTION (11 items)		ATTITUDE TOWARD DISCUSSION (19 items)	
		Alpha Coeff.	Sem	α	Sem
Probing and Redirection	69	0.83	2.50	0.87	3.43
No Probing and Redirection	65	0.84	2.45	0.86	3.19
Filler Activity	65	0.81	2.61	0.88	3.34
Art Activity I	61	0.75	2.81	0.87	3.54
Written Exercise	51	0.82	2.75	0.83	3.47

TABLE B-12

Study I
Correlation Matrix of
Ecology Unit Opinions Subscales

VARIABLE	1	2	3
1. Attitude toward peers		.51	.59
2. Attitude toward teacher			.48
3. Attitude toward curriculum			-

TABLE B-13

Study I
Alpha Coefficients and Standard Errors of Measurement of
Ecology Unit Opinions Subscales

TREATMENT	SAMPLE SIZE	ATTITUDE TOWARD PEERS (5 items)		ATTITUDE TOWARD ECOLOGY TEACHER (18 items)		ATTITUDE TOWARD ECOLOGY CURRICULUM (9 items)	
		Alpha Coeff.	Sem	α	Sem	α	Sem
Probing and Redirection	70	0.73	1.77	0.89	2.83	0.87	2.23
No Probing and Redirection	69	0.78	1.67	0.88	2.72	0.81	2.27
Filler Activity	63	0.71	1.76	0.89	2.91	0.79	2.54
Art Activity I	63	0.74	1.78	0.84	2.22	0.81	2.69
Written Exercises	50	0.71	1.67	0.87	2.52	0.89	1.96

TABLE B-14

Study I
Correlation Matrix of
Ecology Discussion Attitude Subscales

VARIABLE	1	2
1. Attitude toward discussion		.84
2. Attitude toward thought questions		-

TABLE B-15

Study I
Alpha Coefficients and Standard Errors of Measurement of
Ecology Discussion Attitude Subscales

TREATMENT	SAMPLE SIZE	ATTITUDE TOWARD THOUGHT QUESTIONS (11 items)		ATTITUDE TOWARD DISCUSSION (19 items)	
		Alpha Coeff.	Sem	α	Sem
Probing and Redirection	68	0.82	2.57	0.91	3.27
No Probing and Redirection	65	0.87	2.33	0.91	3.00
Filler Activity	65	0.85	2.39	0.89	3.25

TABLE B-16

Study I
Alpha Coefficient and Standard Error of Measurement of Ecology Art Project Scale

TREATMENT	ATTITUDE TOWARD ART PROJECTS (19 items)		
	Sample Size	Alpha Coeff.	Sem
Art Activity (Posttest)	61	0.92	2.99

APPENDIX C

Psychometric Statistics for Study II Measures

TABLE C-1

Study II
Correlation Matrix of Ecology Information Subtests

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12
1. Total Scale (Pre)		.60	.69	.80	.62	.46	.57	.54	.59	.44	.46	.55
2. Intentional Scale II (Pre)			.21	.22	.32	.35	.30	.21	.30	.32	.18	.23
3. 25% Intentional Scale (Pre)				.36	.43	.26	.50	.36	.44	.29	.45	.37
4. Incidental Scale II (Pre)					.51	.33	.41	.52	.47	.31	.33	.51
5. Total Scale (Post)						.81	.80	.87	.84	.67	.66	.77
6. Intentional Scale II (Post)							.52	.56	.65	.69	.40	.53
7. 25% Intentional Scale (Post)								.56	.70	.49	.73	.59
8. Incidental Scale II (Post)									.73	.51	.53	.79
9. Total Scale (Delay)										.83	.80	.87
10. Intentional Scale (Delay)											.54	.59
11. 25% Intentional Scale (Delay)												.56
12. Incidental Scale II (Delay)												

TABLE C-2

Study II
Alpha Coefficients and Standard Errors of Measurement of Ecology Information Subtests

PRETEST

TREATMENT	SAMPLE SIZE	TOTAL SCALE (27 Items)		INTENTIONAL SCALE II (8 Items)		INTENTIONAL 25% HCQ SCALE (7 Items)		INCIDENTAL SCALE II (10 Items)	
		Alpha Coeff	Sem	Alpha Coeff	Sem	Alpha Coeff	Sem	Alpha Coeff	Sem
25% HCQ	72	0.58	2.23	0.09	1.16	0.35	1.15	0.36	1.39
50% HCQ	67	0.49	2.26	0.29	1.15	0.10	1.74	0.38	1.43
75% HCQ	71	0.58	2.24	0.27	1.14	0.14	1.17	0.51	1.36
Art Activity II	148	0.54	2.27	0.18	1.19	0.15	1.19	0.31	1.40

POSTTEST

TREATMENT	SAMPLE SIZE	TOTAL SCALE (27 Items)		INTENTIONAL SCALE II (8 Items)		INTENTIONAL 25% HCQ SCALE (7 Items)		INCIDENTAL SCALE II (10 Items)	
		Alpha Coeff	Sem	Alpha Coeff	Sem	Alpha Coeff	Sem	Alpha Coeff	Sem
25% HCQ	69	0.80	2.15	0.51	1.07	0.38	1.18	0.63	1.32
50% HCQ	67	0.76	2.25	0.50	1.12	0.47	1.21	0.47	1.40
75% HCQ	70	0.83	2.14	0.53	1.03	0.54	1.18	0.69	1.32
Art Activity II	149	0.80	2.28	0.51	1.19	0.48	1.20	0.66	1.37

DELAYED TEST

TREATMENT	SAMPLE	TOTAL SCALE (27 Items)		INTENTIONAL SCALE II (8 Items)		INTENTIONAL 25% HCQ SCALE (7 Items)		INCIDENTAL SCALE II (10 Items)	
		Alpha Coeff	Sem	Alpha Coeff	Sem	Alpha Coeff	Sem	Alpha Coeff	Sem
25% HCQ	67	0.84	2.12	0.68	1.02	0.58	1.11	0.63	1.34
50% HCQ	67	0.81	2.28	0.64	1.16	0.54	1.21	0.59	1.40
75% HCQ	70	0.83	2.20	0.70	1.07	0.46	1.19	0.71	1.34
Art Activity II	142	0.82	2.29	0.60	1.23	0.51	1.19	0.65	1.38

TABLE C-3

Study II

Correlation Matrix of Oral Test Variables

VARIABLES	1	2	3
1. Content Scale (Pre)	-		
2. Logical Extension Scale (Pre)	.69		
3. Content Scale (Post)	.44	.53	
4. Logical Extension Scale (Post)	.38	.62	.67

TABLE C-4

Study II

Correlation Matrix of Essay Test Variables

VARIABLES	1	2	3
1. Content Scale (Pre)	-		
2. Logical Extension Scale (Pre)	.54		
3. Content Scale (Post)	.65	.43	
4. Logical Extension Scale (Post)	.33	.45	.58

TABLE C-5

Study II
Correlation Matrix of
Question-Generating Test Variables
(Paper and Pencil Measure)

VARIABLES	1	2	3	4	5	6	7	8	9	10
1. Nonpertinent Questions (Pre)	-									
2. Pertinent Questions (Pre)	-.15									
3. Specificity (Pre)	.03	.38								
4. Requests for Rationale (Pre)	-.08	.11	-.01							
5. Quality Rating (Pre)	-.31	.05	.07	.06						
6. Nonpertinent Questions (Post)	.38	.04	.12	-.01	-.11					
7. Pertinent Questions (Post)	-.12	.62	.16	.12	.04	.18				
8. Specificity (Post)	-.02	.26	.39	.01	.08	.12	.43			
9. Requests for Rationale (Post)	-.12	.21	.04	.31	.06	-.02	.31	.03		
10. Quality Rating (Post)	-.22	.06	.09	.03	.32	-.14	.07	.24	.12	-

TABLE C-6

Study II
Intraclass Correlation Coefficients for Question-Generating Test Variables (Paper and Pencil Measures)

VARIABLE	Pretest	Posttest
Nonpertinent Questions	.55	.32
Pertinent Questions	.93	.97
Specific Questions	.72	.84
Requests for Rationale	.76	.52
Quality Rating	.42	.52

TABLE C-7

Study II
Correlation Matrix of Question-Generating Test Variables (Oral Measure)

VARIABLES	1	2	3	4	5	6
1. Nonpertinent Questions (Pre)	-					
2. Pertinent Questions (Pre)	-.06					
3. Quality Rating (Pre)	-.04	.67				
4. Nonpertinent Questions (Post)	.13	-.02	-.05			
5. Pertinent Questions (Post)	.05	.54	.35	-.12		
6. Quality Rating (Post)	.13	.30	.35	-.06	.51	-

TABLE C-8

Study II

Correlation Matrix of Word Association Subscales

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12
1. Balance of Nature (Pre)	-											
2. Ecology (Pre)	.41											
3. Alligator (Pre)	.18	.12										
4. Air Pollution (Pre)	.21	.19	-.01									
5. Wolf (Pre)	.24	.19	.62	.11								
6. Water Pollution (Pre)	.19	.14	-.01	.60	.12							
7. Balance of Nature (Post)	.46	.42	.18	.13	.22	.18						
8. Ecology (Post)	.18	.45	.13	.10	.10	.17	.54					
9. Alligator (Post)	.23	.25	.53	.06	.48	.13	.39	.25				
10. Air Pollution (Post)	.07	.05	.04	.33	.04	.38	.16	.25	.11			
11. Wolf (Post)	.24	.26	.88	.13	.58	.16	.39	.30	.65	.08		
12. Water Pollution (Post)	.06	.08	.05	.25	-.01	.36	.17	.35	.12	.79	.05	-

TABLE C-9

Study II
Alpha Coefficients and Standard Errors of Measurement of Word Association Subscales

PRETEST

TREATMENT	SAMPLE SIZE	BALANCE OF NATURE		ECOLOGY		ALLIGATOR		AIR POLLUTION		WOLF		WATER POLLUTION	
		Alpha Coeff.	Sem	Alpha Coeff.	Sem	Alpha Coeff.	Sem	Alpha Coeff.	Sem	Alpha Coeff.	Sem	Alpha Coeff.	Sem
25% HCQ	70	0.75	3.87	0.89	3.42	0.81	4.46	0.34	3.89	0.83	3.92	0.52	3.89
50% HCQ	68	0.78	3.91	0.85	3.89	0.77	4.45	0.12	4.11	0.73	4.17	0.29	4.28
75% HCQ	68	0.81	4.00	0.90	3.80	0.76	4.64	0.54	4.16	0.78	3.91	0.15	3.95
Art Activity II	142	0.73	4.23	0.81	3.94	0.79	4.71	0.40	4.04	0.81	4.18	0.45	4.18

POSTTEST

TREATMENT	SAMPLE SIZE	BALANCE OF NATURE		ECOLOGY		ALLIGATOR		AIR POLLUTION		WOLF		WATER POLLUTION	
		Alpha Coeff.	Sem	Alpha Coeff.	Sem	Alpha Coeff.	Sem	Alpha Coeff.	Sem	Alpha Coeff.	Sem	Alpha Coeff.	Sem
25% HCQ	68	0.85	3.42	0.95	2.70	0.83	3.85	0.33	3.90	0.88	3.25	0.38	3.66
50% HCQ	68	0.80	3.86	0.89	3.12	0.81	4.24	0.62	4.24	0.81	3.87	0.68	4.41
75% HCQ	70	0.74	3.47	0.91	2.75	0.78	4.24	0.13	4.49	0.79	3.76	0.59	4.50
Art Activity II	146	0.87	3.77	0.94	2.98	0.82	4.52	0.56	4.28	0.87	3.98	0.65	4.59

TABLE C-10

Study II
Correlation Matrix of Gall-Crown Discussion Attitude Subscales

VARIABLES	1	2	3	4
1. Attitude toward Thought Questions (Pre)	-			
2. Attitude toward Discussions (Pre)	.64			
3. Attitude toward Thought Questions (Delay)	.55	.52		
4. Attitude toward Discussions (Delay)	.43	.58	.76	

TABLE C-11

Study II
Alpha Coefficients and Standard Errors of Measurement of Gall-Crown Discussion Attitude Subscales

PRETEST

TREATMENT	SAMPLE SIZE	ATTITUDE TOWARD THOUGHT QUESTION (11 items)		ATTITUDE TOWARD DISCUSSION (19 items)	
		Alpha Coeff.	Sem	Alpha Coeff.	Sem
25% HCQ	70	0.78	2.62	0.83	3.24
50% HCQ	68	0.78	2.65	0.80	3.22
75% HCQ	70	0.70	2.74	0.85	3.18
Art Activity II	147	0.71	2.69	0.85	3.33

DELAYED TEST

TREATMENT	SAMPLE SIZE	ATTITUDE TOWARD THOUGHT QUESTION (11 items)		ATTITUDE TOWARD DISCUSSION (19 items)	
		Alpha Coeff.	Sem	Alpha Coeff.	Sem
25% HCQ	69	0.83	2.53	0.92	3.11
50% HCQ	65	0.83	2.46	0.87	3.07
75% HCQ	68	0.89	2.31	0.89	3.29
Art Activity II	145	0.83	2.60	0.89	3.37

TABLE C-12

Study II
Correlation Matrix of Ecology Unit Opinions Subscales

VARIABLE	1	2	3
1. Attitude toward peers	-	.48	.48
2. Attitude toward teacher		-	.79
3. Attitude toward curriculum			-

TABLE C-13

Study II
Alpha Coefficients and Standard Errors of Measurement of Ecology Unit Opinions Subscales

TREATMENT	SAMPLE SIZE	ATTITUDE TOWARD PEERS (5 items)		ATTITUDE TOWARD ECOLOGY TEACHER (19 items)		ATTITUDE TOWARD ECOLOGY CURRICULUM (9 items)	
		Alpha Coeff.	Sem	Alpha Coeff.	Sem	Alpha Coeff.	Sem
25% HCQ	69	0.68	1.51	0.90	2.37	0.88	1.73
50% HCQ	66	0.69	1.50	0.90	2.28	0.83	1.98
75% HCQ	70	0.67	1.50	0.92	2.46	0.87	1.98
Art Activity II	150	0.68	1.73	0.90	2.56	0.87	1.99

TABLE C-14

Study II
Correlation Matrix of
Ecology Discussion Attitude Subscales

VARIABLE	1	2
1. Attitude toward discussion	-	.80
2. Attitude toward thought questions		-

TABLE C-15

Study II
Alpha Coefficients and Standard Errors of Measurement of
Ecology Discussion Attitude Subscales

TREATMENT	SAMPLE SIZE	ATTITUDE TOWARD THOUGHT QUESTIONS (11 items)		ATTITUDE TOWARD DISCUSSION (19 items)	
		Alpha Coeff.	Sem	Alpha Coeff	Sem
25% HCQ	69	0.86	2.32	0.89	2.99
50% HCQ	67	0.87	2.29	0.89	3.08
75% HCQ	71	0.89	2.27	0.89	3.19

TABLE C-16

Study II
Alpha Coefficient and Standard Error of Measurement of Ecology Art Project Scale

TREATMENT	ATTITUDE TOWARD ART PROJECTS (19 items)		
	Sample Size	Alpha Coefficient	Standard Error of Measurement
Art Activity (Posttest)	144	0.91	2.96

APPENDIX D

Study I Descriptive Statistics: Measures of Student Ability, Achievement, Attitudes, and Attendance

TABLE D-1

Comprehensive Test of Basic Skills (Vocabulary, Comprehension, and Total Reading Score) Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	VOCAB	10	4	34.25	4.11	1	4	26.75	10.47	9	4	29.75	5.56	2	3	27.33	4.04		13	VOCAB	1	2	27.00	11.31
	COMP		4	35.00	6.27		4	30.50	13.43		4	33.25	5.50		3	32.67	6.51			COMP		2	26.50	9.19
	TOTAL		4	69.25	6.18		4	57.25	23.77		4	63.00	10.39		3	60.00	6.09			TOTAL		2	53.50	20.51
2	VOCAB	6	5	25.40	5.72	5	5	31.80	5.85	11	3	29.00	4.36	12	6	25.50	7.97		13	VOCAB	2	2	22.50	10.61
	COMP		5	20.00	7.62		5	31.60	13.94		3	28.33	3.21		6	26.67	9.46			COMP		2	33.00	0.00
	TOTAL		5	45.40	12.68		5	63.40	19.40		3	57.33	1.15		6	52.17	17.22			TOTAL		2	55.50	10.61
3	VOCAB	1	5	28.00	5.24	10	5	23.00	9.19	2	3	26.33	10.02	9	5	20.80	8.56		13	VOCAB	9	5	25.80	6.06
	COMP		5	30.40	6.66		5	20.20	5.63		3	28.33	14.36		5	26.00	5.92			COMP		5	24.83	10.42
	TOTAL		5	58.40	11.33		5	43.20	14.13		3	54.67	24.38		5	48.80	12.79			TOTAL		5	58.80	12.32
4	VOCAB	3	6	29.33	9.79	7	6	31.00	7.82	8	5	23.00	9.35	4	5	23.80	6.26		13	VOCAB	10	4	27.17	6.34
	COMP		6	29.83	10.23		6	30.00	10.45		5	24.00	12.86		5	18.40	9.45			COMP		4	33.00	6.89
	TOTAL		6	59.17	19.76		6	61.00	17.03		5	47.00	22.02		5	42.20	14.92			TOTAL		4	52.00	14.56
5	VOCAB	5	3	26.00	8.89	11	6	30.67	6.06	12	5	27.20	5.12	6					14	VOCAB	5	5	34.00	2.92
	COMP		3	25.33	10.50		6	27.83	9.11		5	26.40	9.24			NO	DATA			COMP		5	31.20	7.60
	TOTAL		3	51.33	19.22		6	58.50	13.84		5	53.60	13.70							TOTAL		5	65.20	9.76
6	VOCAB	7	5	31.20	5.89	3	6	27.50	10.71	4	6	19.00	12.71	8	4	25.75	9.00		15	VOCAB	3	6	30.50	7.31
	COMP		6	30.80	9.47		6	29.67	4.84		6	15.50	10.99		4	25.25	11.24			COMP		6	28.33	10.69
	TOTAL		6	62.00	15.30		6	57.17	13.79		6	34.50	23.18		4	51.00	19.78			TOTAL		6	58.83	17.87
7	VOCAB	8	5	32.20	4.66	4	5	14.00	8.75	3	6	29.67	8.82	7	4	25.50	7.85		15	VOCAB	4	4	33.25	2.99
	COMP		5	32.80	3.96		5	14.40	6.31		6	31.50	8.22		4	26.75	8.02			COMP		4	32.75	5.91
	TOTAL		5	65.00	7.25		5	28.40	14.01		6	61.17	16.63		4	52.25	15.59			TOTAL		4	66.00	8.29
8	VOCAB	12	4	28.75	5.97	6	4	23.00	9.13	5	4	26.50	10.34	11	4	20.75	7.97		15	VOCAB	7	7	31.00	6.16
	COMP		4	27.75	5.80		4	22.00	9.20		4	31.00	10.23		4	17.00	5.48			COMP		7	31.14	5.93
	TOTAL		4	56.50	11.09		4	45.00	17.83		4	57.50	20.47		4	37.75	13.23			TOTAL		7	63.43	7.25
9	VOCAB	9	5	29.20	9.55	2	3	33.00	2.65	1	6	29.67	3.27	10	6	26.83	10.53		15	VOCAB	8	4	32.50	5.74
	COMP		5	29.40	11.72		3	35.00	3.46		6	29.50	6.92		6	28.00	10.81			COMP		4	32.00	10.30
	TOTAL		5	58.60	21.07		3	68.00	6.08		6	59.17	9.54		6	54.83	19.60			TOTAL		4	63.75	15.86
10	VOCAB	4	6	28.16	8.18	8	5	34.20	2.05	7	6	23.17	10.36	3	6	23.17	9.13							
	COMP		6	30.83	12.22		5	37.20	3.96		6	24.83	6.74		6	21.17	8.06							
	TOTAL		6	59.00	17.79		5	71.40	5.50		6	48.00	16.88		6	44.33	16.03							
11	VOCAB	11	6	25.83	7.31	12	5	21.00	12.41	6	6	26.67	9.48	5	6	27.33	8.41							
	COMP		6	24.50	8.74		5	25.60	10.46		6	27.17	10.98		6	26.33	11.02							
	TOTAL		6	50.33	15.76		5	46.60	10.46		6	53.83	19.74		6	53.67	19.37							
12	VOCAB	2	4	35.25	1.50	9	6	27.67	3.33	10	6	29.33	5.68	1	5	29.20	7.85							
	COMP		4	36.50	2.52		6	30.50	6.35		6	27.33	9.05		5	32.00	8.34							
	TOTAL		4	71.75	2.52		6	53.17	18.49		6	56.67	13.94		5	61.20	16.08							
TREATMENT	VOCAB			29.46	3.21			26.97	5.86			26.60	3.37			25.09	2.71			VOCAB			29.30	3.80
	COMP			29.42	4.57			27.87	6.42			27.26	4.58			25.47	4.95			COMP			30.53	3.16
EFFECT	TOTAL			58.89	7.62			54.42	12.00			53.87	7.72			50.56	7.23			TOTAL			59.67	5.21

TABLE D-2

Ecology Information Test (Total Scale)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I				
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	
1	PRE	10	6	10.17	2.40	1	6	11.33	3.56	9	6	7.33	1.75	2	6	10.50	2.81	
	POST		5	14.40	7.50		6	18.00	6.75		6	11.17	2.86		6	13.33	3.56	
	DELAY		5	13.67	6.12		6	15.67	6.62		6	10.67	2.16		6	11.33	4.08	
2	PRE	6	6	7.00	1.67	5	6	10.50	1.38	11	6	10.50	2.74	12	7	8.86	1.67	
	POST		6	10.17	2.04		6	15.50	3.27		6	15.50	7.03		7	8.29	3.15	
	DELAY		5	8.00	4.64		6	9.83	6.68		5	16.80	5.89		5	6.00	1.87	
3	PRE	1	6	10.17	2.48	10	6	7.50	2.07	2	5	8.00	2.74	9	6	9.33	2.94	
	POST		6	12.67	5.24		6	8.83	4.26		6	10.83	5.19		6	8.17	2.48	
	DELAY		6	13.83	5.04		6	8.00	2.76		6	10.83	3.55		6	8.50	1.87	
4	PRE	3	6	10.50	2.43	7	6	11.17	3.76	8	6	8.50	3.02	4	5	8.80	3.83	
	POST		6	12.83	6.65		6	18.17	4.02		6	9.33	2.73		4	8.50	3.70	
	DELAY		6	12.50	6.75		6	15.83	5.67		5	9.60	2.70		5	7.60	3.29	
5	PRE	5	6	7.83	1.17	11	6	11.17	2.48	12	6	8.50	2.25	6		NO	DATA	
	POST		6	9.33	5.20		6	16.00	4.20		5	11.20	3.35					
	DELAY		5	11.40	3.85		6	13.83	4.17		5	7.00	5.57					
6	PRE	7	6	11.67	3.56	3	6	9.67	2.66	4	6	8.50	3.02	8	5	7.80	2.77	
	POST		6	16.17	6.04		4	16.25	8.13		6	13.17	5.98		5	10.00	6.20	
	DELAY		6	14.00	6.93		5	14.60	4.56		4	10.75	4.11		5	10.20	5.80	
7	PRE	8	6	9.50	2.07	4	4	7.25	1.71	3	6	10.33	2.66	7	5	9.00	3.80	
	POST		6	13.33	5.43		6	6.66	3.14		5	17.00	4.53		6	10.17	3.19	
	DELAY		5	12.80	5.12		4	11.00	2.16		6	15.00	4.90		6	8.67	3.39	
8	PRE	12	6	9.33	1.21	6	6	9.17	3.66	5	6	9.83	1.47	11	7	8.00	2.58	
	POST		6	13.83	3.76		6	12.33	6.28		5	14.20	3.70		7	12.15	2.79	
	DELAY		5	9.80	2.77		6	11.00	7.82		4	15.50	2.65		7	11.00	4.65	
9	PRE	9	6	10.00	4.56	2	6	9.67	3.33	1	6	10.33	2.33	10	5	9.20	1.92	
	POST		6	15.50	7.34		6	16.83	3.31		6	17.50	3.27		5	9.20	1.64	
	DELAY		5	14.40	6.95		6	15.17	4.49		6	17.50	3.67		6	9.00	2.37	
10	PRE	4	6	9.67	3.93	8	6	10.16	1.60	7	6	10.00	3.41	3	6	8.17	2.40	
	POST		6	17.33	5.43		6	13.67	2.88		6	12.50	3.62		6	10.33	3.33	
	DELAY		5	19.40	2.30		5	13.00	3.32		6	10.00	6.36		5	8.00	4.18	
11	PRE	11	6	12.00	2.45	12	5	9.40	3.21	6	5	9.20	5.54	5	6	7.17	1.72	
	POST		6	15.00	6.07		4	13.00	4.69		6	14.33	6.25		6	9.50	2.43	
	DELAY		6	13.17	5.85		5	9.00	4.06		6	11.83	5.42		6	9.00	2.10	
12	PRE	2	6	10.50	4.85	9	6	10.00	2.53	10	6	10.00	2.90	1	6	12.83	3.76	
	POST		6	16.50	6.38		5	11.00	6.48		6	10.83	5.49		6	13.67	7.71	
	DELAY		6	15.00	7.95		6	7.50	5.79		5	9.80	4.81		6	14.00	7.82	
TREATMENT EFFECT	PRE			9.85	1.40			9.75	1.32			9.25	1.06			9.06	1.54	
	POST			13.92	2.44			13.85	3.64			13.13	2.62			10.30	1.94	
	DELAY			13.16	0.90			12.03	3.03			12.11	3.29			9.39	2.16	

WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	X̄	SD
13	PRE	1	3	8.00	3.60
	POST		3	13.33	3.05
	DELAY		3	13.33	7.23
13	PRE	2	2	12.00	2.82
	POST		3	13.67	5.03
	DELAY		3	13.67	4.16
13	PRE	9	5	10.60	4.39
	POST		5	12.40	7.09
	DELAY		5	11.20	4.82
13	PRE	10	8	10.00	3.50
	POST		7	11.57	5.33
	DELAY		8	10.75	4.13
14	PRE	5	4	10.50	2.52
	POST		4	14.25	3.86
	DELAY		5	11.20	7.89
15	PRE	3	5	10.20	1.79
	POST		6	17.33	2.50
	DELAY		4	18.25	2.63
15	PRE	4	5	4.20	2.49
	POST		5	6.60	2.70
	DELAY		5	3.60	2.30
15	PRE	7	10	9.50	1.96
	POST		10	14.20	2.62
	DELAY		8	13.63	5.04
15	PRE	8	7	9.86	2.73
	POST		7	12.14	6.49
	DELAY		7	8.71	3.04
	PRE			10.14	1.07
	POST			13.83	1.80
	DELAY			12.24	2.88

TABLE D-3

Ecology Information Test (Intentional Scale I)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I				
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	
1	PRE	10	6	4.17	1.33	1	6	3.83	0.98	9	6	3.33	1.50	2	6	3.67	1.75	
	POST		5	7.20	3.35		6	7.33	3.14		6	5.83	1.33		6	5.50	0.84	
	DELAY		5	6.67	2.66		6	7.00	3.35		6	5.83	2.04		6	4.67	1.03	
2	PRE	6	6	1.67	1.21	5	6	3.33	1.37	11	6	4.33	1.75	12	7	3.29	0.95	
	POST		6	5.33	1.63		6	6.83	1.47		6	7.00	3.10		7	3.43	1.51	
	DELAY		5	3.40	2.19		6	3.50	2.74		5	7.00	1.87		5	2.20	1.92	
3	PRE	1	6	3.50	0.84	10	6	3.33	1.21	2	5	3.20	1.92	9	6	3.33	1.50	
	POST		6	5.83	1.94		6	4.00	2.82		6	6.17	1.83		6	3.00	1.41	
	DELAY		6	7.00	1.41		6	3.33	1.63		6	5.83	2.14		6	2.50	0.84	
4	PRE	3	6	4.00	0.63	7	6	4.00	1.09	8	6	3.67	2.07	4	5	4.20	2.59	
	POST		6	5.17	3.11		6	8.00	1.55		6	3.83	0.98		4	3.00	1.83	
	DELAY		6	5.33	2.50		6	6.67	2.42		5	4.60	2.07		5	3.60	2.07	
5	PRE	5	6	3.33	1.03	11	6	3.83	0.75	12	6	2.67	1.50	6		NO	DATA	
	POST		6	4.00	2.28		6	7.17	1.83		5	5.00	2.12					
	DELAY		5	3.40	1.95		6	6.33	1.97		5	3.60	3.21					
6	PRE	7	6	4.17	1.33	3	6	3.67	1.37	4	6	3.17	1.60	8	5	3.20	0.84	
	POST		6	7.00	1.55		4	6.25	3.30		6	5.85	2.40		5	4.40	2.30	
	DELAY		6	5.67	2.73		5	14.60	4.56		4	4.75	3.77		5	4.20	3.03	
7	PRE	8	6	4.00	1.27	4	4	3.25	1.50	3	6	4.67	1.97	7	5	3.60	0.89	
	POST		6	6.00	2.97		6	3.17	1.17		5	8.00	0.71		6	4.33	1.60	
	DELAY		5	6.00	1.87		4	4.00	0.00		6	7.00	1.26		6	4.17	1.37	
8	PRE	12	6	3.50	1.64	6	6	3.83	2.04	5	6	4.17	1.33	11	7	3.14	1.68	
	POST		6	5.83	2.40		6	5.50	2.88		5	6.40	2.70		7	3.71	1.38	
	DELAY		5	4.20	1.92		6	5.17	3.97		4	7.00	0.82		7	3.71	1.89	
9	PRE	9	6	3.17	1.33	2	6	3.67	1.03	1	6	3.50	0.84	10	5	4.00	0.70	
	POST		6	7.00	3.52		6	7.17	1.60		6	8.17	1.47		5	4.80	2.28	
	DELAY		5	6.00	3.24		6	6.83	1.60		6	7.83	0.98		6	3.33	1.86	
10	PRE	4	6	3.83	1.47	8	6	3.67	1.03	7	6	4.67	1.03	3	6	3.17	1.33	
	POST		6	7.00	2.61		6	6.67	2.50		6	6.00	2.10		6	4.33	1.37	
	DELAY		5	8.40	1.95		5	6.80	2.28		6	4.50	3.27		5	3.40	1.52	
11	PRE	11	6	4.33	1.37	12	5	3.40	1.52	6	5	3.00	1.50	5	6	3.00	1.67	
	POST		6	7.17	2.04		4	5.25	2.63		6	6.50	2.81		6	3.50	1.22	
	DELAY		6	6.17	2.48		5	3.40	2.51		6	5.67	2.07		6	3.50	1.76	
12	PRE	2	6	4.17	1.47	9	6	4.17	1.47	10	6	3.66	1.86	1	6	5.00	0.89	
	POST		6	6.83	2.86		5	4.60	2.30		6	4.50	3.39		6	6.17	2.99	
	DELAY		6	6.33	2.88		6	2.50	2.59		5	5.60	2.60		6	5.67	2.73	
TREATMENT EFFECT	PRE			3.65	0.73			3.66	0.29			3.67	0.66			3.60	0.60	
	POST			6.20	1.01			5.99	1.49			6.10	1.28			4.33	1.02	
	DELAY			5.71	2.81			5.14	1.68			5.11	1.26			3.81	1.00	

WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD
13	PRE	1	3	2.00	1.00
	POST		3	6.33	0.58
	DELAY		3	6.00	2.65
13	PRE	2	2	5.50	0.71
	POST		3	6.33	1.53
	DELAY		3	6.33	2.08
13	PRE	3	5	4.40	[illegible]
	POST		5	4.60	3.06
	DELAY		5	3.60	2.61
13	PRE	10	8	4.25	2.05
	POST		7	5.57	1.99
	DELAY		8	3.88	1.46
14	PRE	5	4	4.25	1.26
	POST		4	6.75	1.89
	DELAY		5	5.20	3.11
15	PRE	3	5	4.00	1.67
	POST		6	8.00	1.41
	DELAY		4	7.75	1.26
15	PRE	4	5	10.60	4.10
	POST		5	15.60	5.18
	DELAY		5	9.40	5.03
15	PRE	7	10	4.00	0.94
	POST		10	6.20	1.03
	DELAY		8	5.75	2.38
15	PRE	8	7	3.57	0.79
	POST		7	5.43	3.31
	DELAY		7	4.29	1.80
	PRE			4.06	0.93
	POST			6.20	0.96
	DELAY			5.15	1.43

TABLE D-4

Ecology Information Test (Incidental Scale I)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD		ID		CLASS	N	X̄	SD
1	PRE	10	6	6.00	2.45	1	6	7.50	2.88	9	6	4.00	0.90	2	6	6.83	1.72		13	PRE	1	3	6.00	4.00
	POST		5	7.20	4.32		6	10.67	3.78		6	5.33	2.16		6	7.83	3.06			POST		3	7.00	2.65
	DELAY		5	7.00	4.00		6	8.67	3.61		6	4.83	0.75		6	6.67	3.27			DELAY		3	7.33	4.62
2	PRE	6	6	5.33	0.82	5	6	7.17	0.98	11	6	6.16	2.40	12	7	5.57	2.22		13	PRE	2	2	6.50	2.12
	POST		6	4.83	1.47		6	8.67	2.25		6	8.50	4.27		7	4.86	2.48			POST		3	7.33	3.51
	DELAY		5	4.60	2.61		6	6.33	4.13		5	9.80	4.76		5	3.80	1.90			DELAY		3	7.33	2.08
3	PRE	1	6	6.67	2.73	10	6	4.17	1.72	2	5	4.80	2.17	9	6	6.00	1.55		13	PRE	9	5	6.20	3.03
	POST		6	6.83	3.76		6	4.83	2.56		6	4.67	3.83		6	5.17	1.47			POST		5	7.80	4.32
	DELAY		6	6.83	4.07		6	4.67	1.21		6	5.00	2.10		6	6.00	1.55			DELAY		5	7.60	2.61
4	PRE	3	6	6.50	2.26	7	6	7.17	2.71	8	6	4.83	1.47	4	5	4.60	1.82		13	PRE	10	8	5.75	2.38
	POST		6	7.67	3.83		6	10.17	3.13		6	5.50	2.35		4	5.50	2.08			POST		7	6.00	4.28
	DELAY		6	7.17	4.40		6	9.17	3.76		5	5.00	1.00		5	4.00	3.32			DELAY		8	6.88	2.90
5	PRE	5	6	4.50	0.55	11	6	7.33	2.50	12	6	5.83	1.72	6		NO	DATA		14	PRE	5	4	6.25	1.71
	POST		6	5.33	3.56		6	6.83	2.99		5	6.20	2.05							POST		4	7.50	2.08
	DELAY		5	8.00	2.92		6	7.50	2.43		5	3.40	2.41							DELAY		5	6.00	5.34
6	PRE	7	6	7.50	2.43	3	6	6.00	2.19	4	6	5.33	1.63	8	5	4.60	2.30		15	PRE	3	5	5.80	2.68
	POST		6	9.17	4.96		4	10.00	5.72		6	7.33	4.23		5	5.60	4.16			POST		6	9.33	2.42
	DELAY		6	8.33	4.32		5	8.40	3.29		4	6.00	1.83		5	6.00	4.00			DELAY		4	10.50	1.73
7	PRE	8	6	5.50	2.59	4	4	4.00	0.82	3	6	5.67	1.86	7	5	5.40	3.46		15	PRE	4	5	6.40	1.82
	POST		6	7.33	3.44		6	3.50	2.35		5	9.00	4.24		6	5.33	2.42			POST		5	9.00	2.65
	DELAY		5	6.80	3.35		4	7.00	2.16		6	8.00	3.79		6	4.50	2.41			DELAY		5	5.80	2.95
8	PRE	12	6	5.83	0.75	6	6	5.33	2.80	5	6	5.67	1.03	11	7	4.86	1.46		15	PRE	7	10	5.50	1.90
	POST		6	8.00	1.79		6	6.83	3.97		5	7.80	1.92		7	7.43	2.37			POST		10	8.00	2.16
	DELAY		5	5.60	2.19		6	5.83	4.07		4	8.50	2.08		7	6.29	3.09			DELAY		8	7.88	3.23
9	PRE	9	6	6.83	3.43	2	6	6.00	2.45	1	6	6.83	2.22	10	5	5.20	1.48		15	PRE	8	7	6.29	2.43
	POST		6	8.50	4.04		6	9.67	1.97		6	9.33	2.34		5	4.40	1.52			POST		7	6.71	3.86
	DELAY		5	8.40	3.78		6	8.33	2.94		6	9.67	2.73		6	5.67	0.82			DELAY		7	4.43	1.98
10	PRE	4	6	5.83	3.06	8	6	6.50	1.52	7	6	5.33	2.65	3	6	5.00	1.41							
	POST		6	10.33	2.94		6	7.00	1.10		6	6.50	2.51		6	6.00	2.68							
	DELAY		5	11.00	1.58		5	6.20	1.79		6	5.50	3.33		5	4.60	4.16							
11	PRE	11	6	7.67	1.37	12	5	6.00	1.87	6	5	6.20	4.49	5	6	4.17	1.33							
	POST		6	7.83	4.07		4	7.75	2.63		6	7.83	3.66		6	6.00	1.79							
	DELAY		6	7.00	3.90		5	5.60	1.82		6	6.17	3.86		6	5.50	1.76							
12	PRE	2	6	6.33	3.67	9	6	5.83	1.33	10	6	6.33	1.86	1	6	7.83	3.19							
	POST		6	9.67	3.93		5	6.40	4.22		6	6.33	2.73		6	7.50	5.82							
	DELAY		6	8.67	5.35		6	5.00	3.66		5	4.20	2.77		6	8.33	5.28							
TREATMENT EFFECT	PRE			6.21	0.90			6.08	1.16			5.28	0.78			5.46	1.08			PRE			6.08	0.33
	POST			7.72	1.61			7.86	2.23			7.03	1.61			5.96	1.14			POST			7.83	1.06
	DELAY			7.45	1.62			6.89	1.51			6.34	2.14			5.58	1.32			DELAY			7.08	1.68

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TABLE D-5

Oral Test (Content Scale)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD
1	PRE	10	5	6.80	2.89	1	6	6.08	1.66	9	6	5.92	2.67	2	5	6.30	2.36
	POST		3	7.83	0.58		6	10.17	2.75		5	7.80	3.51		5	6.30	2.52
2	PRE	6	6	6.58	2.27	5	2	4.50	2.83	11	5	5.30	1.92	12	5	4.20	1.57
	POST		4	9.75	0.65		5	6.30	2.08		5	6.80	1.92		3	4.50	2.00
3	PRE	1	6	6.50	1.52	10	4	6.25	3.66	2	3	5.83	3.62	9	5	6.20	2.08
	POST		6	7.83	2.04		6	7.00	2.40		6	[illegible]	3.18		6	7.75	1.81
4	PRE	3	5	5.00	1.17	7	6	5.92	[illegible]	8	[illegible]	5.40	1.79	4	4	6.13	1.93
	POST		6	6.83	2.34		6	8.33	3.17		4	5.00	1.47		4	5.50	3.38
5	PRE	5	5	4.30	0.97	11	4	6.38	1.70	12	5	6.40	2.10	6		NO	DATA
	POST		6	6.42	1.43		3	7.83	2.47		6	6.67	1.66				
6	PRE	7	4	7.38	2.78	3	4	6.25	4.29	4	3	3.83	3.75	8	4	3.38	0.75
	POST		6	9.83	1.17		5	9.60	2.22		6	5.92	2.71		5	3.20	2.31
7	PRE	8	6	5.75	2.81	4	2	7.50	0.71	3	6	5.25	1.99	7	5	6.20	2.31
	POST		6	8.75	2.77		4	7.25	2.99		6	7.75	1.70		6	6.75	3.13
8	PRE	12	4	4.63	3.40	6	5	5.60	1.19	5	5	5.40	1.79	11	5	4.00	2.18
	POST		4	7.25	2.90		5	8.50	1.06		6	8.00	3.13		6	6.50	2.05
9	PRE	9	5	7.90	1.85	2	5	5.80	1.44	1	6	7.83	2.07	10	5	7.80	3.21
	POST		5	9.50	2.55		6	7.42	1.69		6	8.92	2.08		5	9.10	3.58
10	PRE	4	5	5.70	3.96	8	5	5.60	1.52	7	6	6.33	1.17	3	6	5.75	2.04
	POST		4	9.13	0.75		6	8.50	2.12		6	8.33	2.54		6	5.75	2.64
11	PRE	11	5	6.30	2.02	12	3	3.17	2.75	6	6	6.17	3.33	5	5	5.30	1.92
	POST		6	9.42	2.76		5	7.50	2.37		6	7.58	3.11		5	6.40	1.52
12	PRE	2	5	8.80	1.35	9	6	5.33	2.79	10	5	7.60	3.01	1	5	5.00	2.57
	POST		6	11.50	4.10		5	8.90	3.31		5	8.70	1.60		5	6.10	3.52
TREATMENT EFFECT	PRE			6.30	1.33			5.86	1.27			5.94	1.07			5.48	1.27
	POST			8.67	1.42			9.99	2.67			7.49	1.18			6.17	1.54

WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	X̄	SD
13	PRE	1	3	9.50	0.50
	POST		3	10.83	2.36
13	PRE	2	2	5.50	2.83
	POST		3	7.50	1.32
13	PRE	9	5	6.90	1.78
	POST		4	6.25	2.60
13	PRE	10	7	6.64	2.23
	POST		7	6.50	2.50
14	PRE	5	2	7.25	1.77
			0	no	data
15	PRE	3	5	7.30	1.10
	POST		5	7.00	2.32
15	PRE	4	3	7.83	2.31
	POST		5	9.00	3.02
15	PRE	7	9	5.78	1.52
	POST		10	7.15	2.95
15	PRE	8	5	5.70	2.25
	POST		7	6.71	2.81
	PRE			6.93	1.26
	POST			7.62	1.55

TABLE D-6

Oral Test (Logical Extension Scale)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD		ID		CLASS	N	X̄	SD
1	PRE	10	5	2.30	2.11	1	6	2.67	0.82	9	6	1.42	1.59	2	5	3.60	2.82		13	PRE	1	3	4.83	1.26
	POST		3	2.00	1.32		6	5.25	2.38		4	5.00	3.32		5	2.10	1.08			POST		3	4.17	1.61
2	PRE	6	6	1.17	1.21	5	2	0.50	0.71	11	4	1.75	1.04	12	5	0.70	0.27		13	PRE	2	2	1.50	0.71
	POST		4	5.34	1.84		5	2.70	2.89		5	2.20	0.76		3	0.83	1.04			POST		3	2.67	2.02
3	PRE	1	6	2.25	2.12	10	4	1.00	1.41	2	3	0.67	0.29	9	5	1.40	1.29		13	PRE	9	5	1.40	0.82
	POST		5	2.40	1.29		6	1.50	1.58		6	3.25	2.58		6	2.92	1.16			POST		3	1.67	0.76
4.	PRE	3	5	0.86	0.84	7	6	0.50	0.45	8	5	1.80	2.66	4	3	2.17	2.02		13	PRE	10	7	2.14	1.73
	POST		5	3.70	0.91		6	3.00	1.38		4	1.13	0.75		3	2.00	2.18			POST		7	1.64	1.41
5	PRE	5	4	1.13	1.03	11	4	1.75	2.18	12	4	1.13	0.95	6		NO	DATA		14	PRE	5	2	4.00	2.12
	POST		6	2.58	1.39		3	2.67	1.04		6	2.42	1.93							POST		0	no	data
6	PRE	7	4	1.38	0.95	3	4	2.25	2.53	4	2	1.25	1.77	8	3	0.83	0.76		15	PRE	3	4	2.25	1.55
	POST		6	3.42	1.24		5	4.50	1.00		6	2.33	2.32		5	0.40	0.65			POST		5	1.80	1.44
7	PRE	8	6	3.17	2.70	4	2	3.75	1.06	3	4	2.13	1.49	7	5	1.30	1.30		15	PRE	4	3	1.33	0.29
	POST		6	2.17	1.99		4	2.63	2.06		5	2.70	2.41		6	1.42	1.24			POST		5	2.80	1.96
8	PRE	12	2	0.00	0.00	6	5	1.90	1.52	5	4	1.50	1.29	11	5	0.70	0.97		15	PRE	7	7	1.36	2.25
	POST		4	2.13	1.65		5	3.60	1.39		6	3.50	2.88		6	1.58	1.43			POST		8	2.69	4.48
9	PRE	9	5	2.40	2.33	2	5	2.70	2.02	1	6	3.67	2.99	10	4	4.38	4.09		15	PRE	8	4	1.88	1.65
	POST		5	4.70	2.11		6	3.00	3.30		6	2.42	2.35		5	6.30	7.16			POST		6	2.92	1.77
10	PRE	4	4	1.88	1.38	8	5	1.40	1.82	7	5	1.10	0.89	3	5	1.10	0.65							
	POST		4	5.38	2.06		6	3.33	1.57		6	3.25	1.57		5	0.70	0.44							
11	PRE	11	5	2.20	2.36	12				6	6	2.33	2.21	5	5	0.30	0.45							
	POST		6	4.75	3.00		5	1.90	1.71		6	3.92	2.63			2.70	1.52							
12	PRE	2	5	4.00	1.77	9	6	1.58	1.39	10	5	2.30	0.97	1	5	1.40	2.07							
	POST		6	4.92	1.66		4	6.00	1.87		5	3.00	1.54		4	1.00	1.68							
TREATMENT EFFECT	PRE			1.89	1.08			1.81	0.99			1.75	0.79			1.62	1.28			PRE			2.30	1.26
	POST			3.62	1.34			3.34	1.32			2.92	0.98			1.99	1.64			POST			2.79	1.46

TABLE D-7

Essay Test (Content Scale)
Study I Descriptive Statistics

ECOLOGY TEACHER ID		PROBING AND REDIRECTION TREATMENT CLASS	N	$\bar{X}$	SD	NO PROBING AND REDIRECTION TREATMENT CLASS	N	$\bar{X}$	SD	FILLER ACTIVITY TREATMENT CLASS	N	$\bar{X}$	SD	ART ACTIVITY TREATMENT I CLASS	N	$\bar{X}$	SD
1	PRE	10	6	8.25	5.86	1	6	12.67	3.50	9	6	12.33	3.44	2	6	12.67	3.13
	POST		6	9.25	4.37		6	14.00	4.04		6	7.25	3.63		6	12.08	3.34
2	PRE	6	6	8.42	3.71	5	5	8.90	3.27	11	6	11.33	2.58	12	6	8.00	4.44
	POST		5	11.80	12.28		6	10.25	3.37		6	12.50	4.33		7	7.42	4.29
3	PRE	1	5	10.50	1.97	10	6	5.58	2.96	2	5	10.50	3.34	9	6	7.50	2.79
	POST		6	12.25	4.32		6	7.08	4.61		6	11.42	3.96		6	6.00	2.97
4	PRE	3	6	8.83	3.64	7	6	10.42	4.85	8	6	5.92	4.08	4	5	6.00	3.32
	POST		6	10.50	6.75		6	13.50	5.59		6	8.25	4.22		5	4.30	3.37
5	PRE	5	6	7.00	4.00	11	6	11.50	2.88	12	4	3.63	2.90	6		NO	DATA
	POST		6	7.25	4.72		5	11.60	1.71		5	8.10	6.19				
6	PRE	7	6	11.75	2.04	3	6	11.25	3.63	4	6	5.00	3.54	8	5	9.90	6.28
	POST		6	12.33	3.09		4	12.13	3.35		5	6.40	3.29		5	9.50	3.82
7	PRE	8	6	11.42	6.16	4	5	6.60	3.11	3	6	10.67	4.30	7	5	7.80	2.68
	POST		5	12.90	6.77		5	5.20	4.16		6	8.75	5.91		6	10.08	2.73
8	PRE	12	6	8.08	3.12	6	4	5.88	4.15	5	6	9.17	4.25	11	6	5.75	6.03
	POST		6	10.42	2.29		6	10.25	4.13		4	10.25	4.87		6	9.00	4.11
9	PRE	9	6	11.58	4.77	2	6	10.83	2.54	1	5	11.60	1.92	10	5	9.30	2.28
	POST		6	9.92	3.46		6	12.33	3.06		6	11.25	3.03		5	9.40	1.08
10	PRE	4	6	8.75	3.08	8	5	11.60	3.56	7	6	8.58	2.44	3	6	10.50	11.58
	POST		6	9.83	1.61		6	12.00	2.57		6	10.75	4.49		6	7.75	6.01
11	PRE	11	6	8.58	4.05	12	3	7.33	5.84	6	6	9.08	3.84	5	6	5.75	2.95
	POST		6	12.42	4.72		6	8.75	3.71		6	11.42	3.09		6	7.08	2.56
12	PRE	2	6	11.50	3.13	9	6	10.42	2.52	10	6	9.42	3.12	1	5	9.20	4.59
	POST		5	13.10	1.78		5	12.10	3.23		6	11.17	3.62		6	10.50	4.51
TREATMENT EFFECT	PRE			9.55	1.68			9.41	2.46			8.93	2.75			8.40	2.18
	POST			11.00	1.76			10.77	2.62			9.79	1.95			8.46	2.21

WRITTEN EXERCISE TEACHER ID		WRITTEN EXERCISE TREATMENT CLASS	N	$\bar{X}$	SD
13	PRE	1	3	10.83	1.61
	POST		3	11.67	2.08
13	PRE	2	3	8.00	2.65
	POST		2	7.25	0.35
13	PRE	9	5	11.40	3.77
	POST		4	6.63	3.01
13	PRE	10	8	8.56	4.80
	POST		7	8.64	3.63
14	PRE	5	4	8.00	4.42
	POST		4	10.13	5.04
15	PRE	3	6	11.25	2.81
	POST		6	10.00	1.05
15	PRE	4	4	10.88	7.39
	POST		5	10.20	5.09
15	PRE	7	10	10.00	4.21
	POST		10	12.20	3.87
15	PRE	8	8	11.94	2.32
	POST		6	11.42	2.78
	PRE			10.09	1.53
	POST			9.79	1.94

TABLE D-8

Essay Test (Logical Extension Scale)
Study I Descriptive Statistics

ECOLOGY TEACHER ID		PROBING AND REDIRECTION TREATMENT CLASS	N	$\bar{X}$	SD	NO PROBING AND REDIRECTION TREATMENT CLASS	N	$\bar{X}$	SD	FILLER ACTIVITY TREATMENT CLASS	N	$\bar{X}$	SD	ART ACTIVITY TREATMENT I CLASS	N	$\bar{X}$	SD	
1	PRE	10	6	1.17	1.75	1	6	1.83	1.34	9	6	1.58	1.96	2	5	2.25	1.73	
	POST		6	1.25	1.41		6	2.08	1.24		6	0.58	1.20		6	1.08	1.50	
2	PRE	6	6	0.42	0.49	5	6	0.58	0.58	11	6	1.42	1.86	12	7	0.36	0.63	
	POST		6	0.75	0.94		6	2.17	2.01		6	1.75	1.64		7	0.50	0.50	
3	PRE	1	6	1.17	1.08	10	6	0.33	0.41	2	6	2.83	3.04	9	6	0.83	0.41	
	POST		6	2.25	1.75		6	0.75	0.88		6	0.67	1.08		6	0.75	0.69	
4	PRE	3	6	1.58	2.13	7	6	0.83	0.98	8	6	0.17	0.26	4	5	0.70	0.84	
	POST		6	1.67	1.83		6	2.45	1.66		6	0.75	0.99		5	0.10	0.22	
5	PRE	5	6	0.92	1.16	11	6	0.83	0.68	12	6	0.25	0.61	6		NO	DATA	
	POST		6	1.17	0.82		6	0.67	0.61		6	1.00	1.22					
6	PRE	7	6	1.33	0.68	3	6	2.33	2.86	4	6	0.33	0.61	8	5	1.00	1.00	
	POST		6	1.75	0.94		6	2.00	2.07		6	0.25	0.27		5	1.20	1.26	
7	PRE	8	6	0.75	0.76	4	6	0.50	1.00	3	6	3.17	3.71	7	6	0.92	[illegible]	
	POST		6	1.50	3.21		6	0.25	0.61		6	1.58	1.74		6	1.25	0.52	
8	PRE	12	6	0.83	0.93	6	6	0.00	0.00	5	6	0.92	0.80	11	7	0.36	0.95	
	POST		6	1.25	1.21		6	1.08	1.50		6	1.42	1.69		7	0.50	0.71	
9	PRE	9	6	1.75	1.92	2	6	1.42	1.11	1	6	2.25	1.92	10	6	1.67	1.40	
	POST		6	1.00	1.14		6	1.00	1.22		6	1.25	1.04		6	0.67	0.98	
10	PRE	4	6	0.17	0.41	8	6	0.92	1.56	7	6	1.08	0.86	3	6	2.08	4.62	
	POST		6	0.58	0.49		6	0.92	1.28		6	1.42	0.86		6	0.67	1.40	
11	PRE	11	6	0.67	0.41	12	6	0.50	1.22	6	6	1.00	0.84	5	6	0.42	0.66	
	POST		6	2.17	1.92		6	0.75	0.61		6	1.00	0.71		6	0.25	0.61	
12	PRE	2	6	2.75	0.88	9	6	1.25	0.61	10	6	0.25	0.42	1	6	1.42	1.20	
	POST		6	1.08	0.86		6	1.00	1.11		6	1.08	0.97		6	1.67	1.72	
TREATMENT EFFECT	PRE			1.12	0.69			0.94	0.66			1.27	1.02			1.09	0.68	
	POST			1.37	0.52			1.25	0.71			1.06	0.45			0.78	0.47	

WRITTEN EXERCISE TEACHER ID		WRITTEN EXERCISE TREATMENT CLASS	N	$\bar{X}$	SD
13	PRE	1	3	1.50	1.00
	POST		3	2.00	0.50
13	PRE	2	3	1.33	0.76
	POST		3	0.33	0.58
13	PRE	9	5	1.60	1.82
	POST		5	0.70	0.76
13	PRE	10	8	1.56	2.23
	POST		8	0.94	0.98
14	PRE	5	5	0.80	0.57
	POST		5	0.40	0.42
15	PRE	3	6	1.58	1.16
	POST		6	0.75	0.76
15	PRE	4	5	1.90	3.05
	POST		5	0.70	0.84
15	PRE	7	10	1.40	1.52
	POST		10	1.65	1.40
15	PRE	8	8	1.50	1.20
	POST		8	0.88	1.46
	PRE			1.46	0.30
	POST			0.93	0.55

TABLE D-9

Transfer Test (Content Scale)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT			NO PROBING AND REDIRECTION TREATMENT			FILLER ACTIVITY TREATMENT			ART ACTIVITY TREATMENT I				WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT		
ID		CLASS N	X̄	SD	CLASS N	X̄	SD	CLASS N	X̄	SD	CLASS N	X̄	SD		ID		CLASS N	X̄	SD
1	DELAY	10	5.75	3.19	1	12.08	3.17	9	6.50	5.02	2	8.83	2.93		13	DELAY	1 0	NO	DATA
2	DELAY	6	7.60	2.97	5	7.50	3.18	11	8.13	3.28	12	9.17	6.05		13	DELAY	2 3	8.83	3.62
3	DELAY	1	12.50	6.59	10	7.33	5.13	2	9.67	4.17	9	6.25	3.95		13	DELAY	9 5	5.90	4.98
4	DELAY	3	6.75	3.27	7	7.92	4.89	8	5.58	3.44	4	3.90	3.58		13	DELAY	10 7	4.43	2.56
5	DELAY	5	5.83	3.95	11	11.75	3.17	12	3.80	3.19	6	NO	DATA		14	DELAY	5 4	8.75	4.44
6	DELAY	7	8.58	4.34	3	6.60	3.31	4	5.13	3.66	8	5.50	1.84		15	DELAY	3 5	7.10	2.10
7	DELAY	8	9.42	4.27	4	6.30	4.66	3	7.33	5.12	7	5.17	2.23		15	DELAY	4 5	6.50	4.21
8	DELAY	12	6.20	2.84	6	6.75	3.14	5	8.00	5.67	11	5.43	3.94		15	DELAY	7 10	5.95	3.48
9	DELAY	9	8.75	4.52	2	9.20	0.27	1	9.50	3.10	10	5.33	2.73		15	DELAY	9 8	6.94	2.21
10	DELAY	4	7.30	2.49	8	8.40	2.63	7	4.92	3.22	3	2.88	1.65						
11	DELAY	11	10.42	3.72	12	5.33	3.20	6	7.33	1.97	5	5.08	2.75						
12	DELAY	2	11.60	1.85	9	9.83	2.62	10	6.00	2.92	1	11.92	4.83						
TREATMENT EFFECT	DELAY		8.39	2.24		8.25	2.11		6.82	1.83		6.31	2.62			DELAY		6.80	1.48

TABLE D-10

Transfer Test (Logical Extension Scale)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	DELAY	10	6	0.17	0.41	1	6	3.00	1.87	9	6	1.67	2.01	2	6	1.92	1.77		13	DELAY	1		NO	DATA
2	DELAY	6	5	1.00	0.79	5	6	2.08	2.11	11	4	1.75	1.94	12	6	1.83	1.47		13	DELAY	2	3	2.50	2.60
3	DELAY	1	6	3.33	3.40	10	6	0.75	1.41	2	6	2.00	2.35	9	4	1.50	2.35		13	DELAY	9	5	0.80	0.57
4	DELAY	3	6	1.25	1.94	7	6	1.08	1.43	8	6	1.08	1.24	4	5	0.00	0.00		13	DELAY	10	7	0.07	0.19
5	DELAY	5	6	1.50	1.67	11	6	2.25	2.04	12	5	0.90	1.08	6		NO	DATA		14	DELAY	5	2	3.13	3.15
6	DELAY	7	6	1.42	1.16	3	5	2.50	1.54	4	4	0.13	0.25	8	5	0.60	0.08		15	DELAY	3	5	1.50	1.73
7	DELAY	8	6	2.33	3.16	4	5	0.80	1.30	3	6	1.75	1.89	7	6	0.42	0.66		15	DELAY	4	5	1.70	3.53
8	DELAY	12	5	0.70	0.57	6	6	1.42	1.56	5	4	2.13	2.02	11	7	0.79	1.07		15	DELAY	7	10	1.00	1.41
9	DELAY	9	6	1.42	1.83	2	5	1.30	0.45	1	5	2.60	1.39	10	6	0.33	0.41		15	DELAY	8	8	0.69	0.59
10	DELAY	4	5	0.40	0.65	8	5	0.60	0.82	7	6	0.17	0.26	3	4	0.00	0.00							
11	DELAY	11	6	2.08	1.69	12	6	0.92	1.39	6	6	1.67	2.96	5	6	0.67	0.82							
12	DELAY	2	5	2.60	1.79	9	6	1.92	1.39	10	6	0.92	1.50	1	6	2.50	1.73							
TREATMENT EFFECT	DELAY			1.56	0.88			1.55	0.78			1.39	0.77			0.96	0.84			DELAY			1.42	1.01

TABLE D-11

Question-Generating Test, Paper-and-Pencil Measure (Number of Nonpertinent Questions)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	PRE	10	6	.00	.00	1	5	.50	.50	9	6	.33	.41	2	6	.17	.41		13	PRE	1	3	.33	.58
	POST		6	.00	.00		5	.50	.87		6	1.67	2.09		6	.17	.26			POST		3	.00	.00
2	PRE	6	6	.58	.59	5	5	.11	.16	11	5	.40	.55	12	7	4.64	4.75		13	PRE	2	2	.00	.00
	POST		6	.13	.13		6	.58	.97		5	.60	.89		7	1.50	1.12			POST		3	1.00	1.00
3	PRE	1	6	.67	.98	10	6	.11	.17	2	5	.90	1.34	9	6	6.42	7.66		13	PRE	9	5	2.20	2.84
	POST		6	.75	.82		6	.33	.41		6	.33	.41		6	3.08	5.15			POST		5	1.80	1.57
4	PRE	3	5	.10	.22	7	5	.20	.27	8	6	.08	.20	4	4	5.13	1.59		13	PRE	10	8	.81	1.07
	POST		6	.33	.41		6	.17	.26		6	.25	.42		4	.00	.00			POST		7	.07	.19
5	PRE	5	6	.31	.42	11	5	.30	.45	12	4	.13	.25	6		NO	DATA		14	PRE	5	4	.88	.85
	POST		6	.12	.20		6	.17	.26		5	.10	.22							POST		4	.50	.71
6	PRE	7	6	.25	.61	3	6	.33	.41	4	6	.33	.61	8	5	1.00	1.70		15	PRE	3	6	.08	.20
	POST		6	.67	.82		5	.60	.11		4	.13	.25		5	.30	.27			POST		6	.33	.61
7	PRE	8	6	.00	.00	4	4	.13	.25	3	6	.33	.82	7	5	.20	.27		15	PRE	4	4	.00	.00
	POST		6	.17	.41		6	.17	.26		6	.17	.41		5	.40	.65			POST		5	1.20	2.17
8	PRE	12	5	.11	.17	6	6	1.83	2.88	5	5	.10	.22	11	6	2.33	4.17		15	PRE	7	7	1.00	2.65
	POST		6	.00	.00		6	.83	.98		5	.10	.25		7	.93	1.17			POST		10	.10	.32
9	PRE	9	6	.36	.71	2	6	.25	.42	1	5	.10	.22	10	5	5.96	.82		15	PRE	8	6	.33	.61
	POST		6	.12	.18		6	.33	.67		6	.08	.20		5	1.60	3.58			POST		7	.07	.19
10	PRE	4	6	.00	.00	8	6	.00	.00	7	5	1.80	2.75	3	6	5.50	.99							
	POST		6	.08	.20		6	.00	.00		5	.50	.87		5	.80	.57							
11	PRE	11	6	.50	.63	12	6	1.75	1.37	6	5	2.40	5.10	5	6	1.75	2.38							
	POST		5	.30	.45		6	.67	1.08		6	.83	1.81		6	.92	1.11							
12	PRE	2	6	.17	.41	9	6	1.00	1.82	10	6	.25	.42	1	5	.30	.67							
	POST		6	.25	.42		5	1.90	1.78		6	.00	.00		5	.60	.89							
TREATMENT EFFECT	PRE			0.84	1.22			0.71	0.63			0.60	0.75			1.90	2.00			PRE			0.63	0.70
	POST			0.52	0.48			0.52	0.50			0.40	0.47			0.94	0.88			POST			0.56	0.63

TABLE D-12

Question-Generating Test, Paper-and-Pencil Measure (Number of Pertinent Questions)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	PRE	10	6	15.00	6.60	1	5	11.60	5.08	9	6	13.92	3.07	2	6	15.00	7.01		13	PRE	1	3	15.67	8.33
	POST		6	10.00	3.05		5	12.60	7.72		6	10.58	3.10		6	14.17	5.87			POST		3	20.00	10.44
2	PRE	6	6	17.08	5.50	5	5	15.40	7.83	11	5	9.00	1.87	12	7	12.36	13.90		13	PRE	2	2	15.00	2.83
	POST		6	10.92	4.39		6	8.33	3.66		5	13.00	8.06		7	14.64	13.49			POST		3	16.17	6.05
3	PRE	1	6	20.25	4.48	10	6	12.00	2.98	2	5	12.50	4.70	9	6	13.17	13.48		13	PRE	9	5	15.20	7.13
	POST		6	20.00	7.27		6	11.33	5.98		6	12.58	6.76		6	9.83	5.89			POST		5	12.00	5.04
4	PRE	3	5	14.90	8.92	7	5	16.60	7.41	8	6	12.75	4.78	4	5	10.10	7.36		13	PRE	10	8	15.31	5.50
	POST		6	9.00	8.43		6	11.83	6.09		6	11.83	6.20		4	3.00	1.83			POST		7	12.43	5.30
5	PRE	5	6	12.92	8.46	11	5	12.30	6.98	12	4	8.38	2.06	6		NO	DATA		14	PRE	5	4	15.62	5.79
	POST		6	13.33	7.59		6	13.30	5.37		5	6.90	3.54							POST		4	14.50	4.76
6	PRE	7	6	13.58	2.90	3	6	15.83	8.53	4	6	10.17	8.28	8	5	8.70	3.21		15	PRE	3	6	11.25	2.56
	POST		6	12.92	4.03		5	12.30	6.14		4	4.75	4.65		5	7.70	4.15			POST		6	10.17	3.67
7	PRE	8	6	11.92	4.32	4	4	13.50	7.90	3	6	14.42	9.89	7	5	14.70	2.17		15	PRE	4	4	14.75	4.99
	POST		6	18.92	6.07		6	6.42	6.44		6	10.00	7.95		5	11.80	2.39			POST		5	7.20	4.78
8	PRE	12	5	1.10	1.75	6	6	15.42	5.90	5	5	15.10	4.56	11	6	5.67	3.34		15	PRE	7	7	13.86	3.13
	POST		6	8.17	3.25		6	11.17	4.12		5	14.40	6.23		7	9.36	4.66			POST		10	10.95	5.69
9	PRE	9	6	14.67	10.25	2	6	18.00	2.90	1	5	18.10	7.68	10	5	12.20	4.56		15	PRE	8	6	17.58	5.85
	POST		6	12.83	4.49		6	17.33	7.61		6	19.75	8.54		5	9.20	5.59			POST		7	16.57	4.50
10	PRE	4	6	10.00	4.00	8	6	15.08	9.12	7	5	10.80	4.62	3	5	11.70	6.52							
	POST		6	7.17	1.84		6	15.67	5.42		5	11.00	6.94		5	7.00	6.82							
11	PRE	11	6	11.33	6.51	12	6	11.75	4.33	6	5	19.10	6.04	5	6	13.83	7.12							
	POST		5	10.20	5.93		6	7.67	2.14		6	14.75	7.59		6	11.92	5.60							
12	PRE	2	6	16.17	5.78	9	6	20.42	6.23	10	6	13.42	4.80	1	5	15.30	1.89							
	POST		6	19.25	5.27		5	12.70	6.21		6	10.67	2.44		5	14.30	9.04							
TREATMENT EFFECT	PRE			14.08	2.89			14.82	2.73			13.14	3.32			12.07	2.94			PRE			14.92	1.70
	POST			12.72	4.44			11.72	3.14			11.68	3.82			10.26	3.58			POST			13.33	3.88

TABLE D-13

Question-Generating Test, Paper-and-Pencil Measure (Number of Specific Questions)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	PRE POST	10	6 6	6.25 5.00	4.54 3.99	1	5 5	3.00 1.40	2.37 0.89	9	6 6	2.58 1.53	1.93 1.39	2	6 6	2.75 2.33	2.14 2.71		13	PRE POST	1	3 3	2.50 4.33	1.50 0.76
2	PRE POST	6	6 6	4.92 2.33	3.99 4.38	5	5 6	5.80 4.67	3.17 2.86	11	5 5	3.90 6.00	1.98 5.61	12	7 7	3.00 1.29	3.11 1.22		13	PRE POST	2	2 3	0.00 3.00	0.00 2.78
3	PRE POST	1	6 6	4.67 4.67	4.02 3.24	10	6 6	3.33 2.42	2.40 2.15	2	5 6	2.50 3.50	2.15 2.53	9	6 6	1.33 1.68	1.54 2.54		13	PRE POST	9	5 5	7.50 6.20	4.84 3.92
4	PRE POST	3	5 6	3.40 1.25	2.07 1.67	7	5 6	2.80 2.25	1.75 2.88	8	6 6	1.58 2.58	1.69 2.48	4	5 4	3.70 1.00	2.82 1.22		13	PRE POST	10	8 7	4.75 4.07	3.45 5.56
5	PRE POST	5	6 6	1.92 3.00	1.69 3.12	11	5 6	3.90 4.58	0.96 2.82	12	4 5	1.25 0.90	1.19 0.89	6		NO	DATA		14	PRE POST	5	4 4	4.88 4.25	3.06 3.75
6	PRE POST	7	4 6	4.67 3.50	1.54 2.47	3	6 5	5.92 2.70	3.76 2.52	4	6 4	3.67 0.75	4.45 1.50	8	5 5	2.10 1.00	1.82 1.00		15	PRE POST	3	6 6	4.67 2.33	2.52 2.88
7	PRE POST	8	6 6	2.00 4.25	1.41 3.66	4	4 6	5.62 2.67	3.64 4.24	3	6 6	7.50 3.17	5.06 4.34	7	5 5	5.40 2.50	3.42 1.17		15	PRE POST	4	4 5	5.12 3.10	1.60 2.48
8	PRE POST	12	5 6	2.80 1.58	1.30 0.97	6	6 6	2.42 1.08	1.43 1.74	5	5 5	4.30 4.80	4.47 2.31	11	6 7	3.00 1.64	1.98 1.84		15	PRE POST	7	7 10	2.79 1.70	1.15 2.80
9	PRE POST	9	6 6	2.75 5.08	3.37 2.54	2	6 6	1.67 3.08	1.72 3.01	1	5 6	5.20 4.92	3.29 3.83	10	5 5	5.70 3.10	4.78 3.81		15	PRE POST	8	6 7	2.75 6.36	2.07 5.45
10	PRE POST	4	6 6	4.83 1.92	2.42 1.20	8	6 6	4.67 5.75	5.08 3.06	7	5 5	2.80 2.10	2.59 2.30	3	5 5	3.80 2.40	3.29 4.05							
11	PRE POST	11	6 5	2.50 2.70	1.95 2.64	12	6 6	1.50 0.75	2.28 0.76	6	5 6	3.20 3.58	3.49 5.01	5	6 6	2.50 3.75	2.41 2.88							
12	PRE POST	2	6 6	1.42 4.33	1.56 8.26	9	6 5	5.42 4.20	3.41 4.48	10	6 6	3.50 2.67	2.70 1.97	1	5 5	3.00 2.60	3.92 2.22							
TREATMENT EFFECT	PRE POST			3.51 3.30	1.51 1.36			3.84 2.96	1.62 1.56			3.50 3.05	1.68 1.63			3.30 2.11	1.31 0.89			PRE POST			3.88 3.87	2.13 1.48

TABLE D-14

Question-Generating Test, Paper-and-Pencil Measure (Number of Requests for Rationale)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD		ID		CLASS	N	X̄	SD
1	PRE	10	6	0.58	1.43	1	5	2.20	3.03	9	6	0.50	0.84	2	5	1.08	1.96		13	PRE	1	3	0.33	0.58
	POST		6	1.00	2.45		5	1.60	2.30		6	0.42	0.49		6	0.83	1.17			POST		3	1.50	2.18
2	PRE	6	6	0.17	0.41	5	5	1.00	1.73	11	5	0.00	0.00	12	7	0.00	0.00		13	PRE	2	2	1.50	2.12
	POST		6	0.25	0.42		6	0.42	0.49		5	1.20	1.79		7	0.00	0.00			POST		3	1.33	2.31
3	PRE	1	6	4.67	4.02	10	6	0.00	0.00	2	5	1.00	1.73	9	6	0.83	1.81		13	PRE	9	5	0.80	1.10
	POST		6	4.67	3.24		6	0.33	0.52		6	0.50	0.55		6	0.58	0.80			POST		5	0.20	0.45
4	PRE	3	5	0.20	0.45	7	5	0.00	0.00	8	6	0.00	0.00	4	5	0.30	0.67		13	PRE	10	8	0.38	1.06
	POST		6	0.42	0.80		6	0.42	1.02		6	0.00	0.00		4	0.00	0.00			POST		7	1.00	1.56
5	PRE	5	6	0.50	1.22	11	5	0.00	0.00	12	4	0.00	0.00	6		NO	DATA		14	PRE	5	4	1.00	2.00
	POST		6	0.50	1.22		6	0.83	1.33		5	0.40	0.89							POST		4	1.12	1.03
6	PRE	7	6	0.00	0.00	3	6	0.50	1.22	4	6	0.00	0.00	8	5	0.00	0.00		15	PRE	3	6	0.00	0.00
	POST		6	0.33	0.82		5	0.40	0.55		4	0.25	0.50		5	0.10	0.22			POST		6	0.00	0.00
7	PRE	8	6	0.00	0.00	4	4	0.00	0.00	3	6	0.00	0.00	7	5	0.00	0.00		15	PRE	4	4	0.25	0.50
	POST		6	0.00	0.00		6	0.00	0.00		6	0.00	0.00		5	0.00	0.00			POST		5	0.40	0.89
8	PRE	12	5	0.00	0.00	6	6	0.50	0.63	5	5	2.00	3.08	11	6	0.00	0.00		15	PRE	7	7	0.14	0.38
	POST		6	0.17	0.41		6	0.08	0.20		5	1.60	1.52		7	0.43	1.13			POST		10	0.70	1.27
9	PRE	9	6	1.33	2.34	2	6	0.75	1.40	1	5	0.80	1.30	10	5	0.20	0.45		15	PRE	8	6	0.00	0.00
	POST		6	1.42	2.20		6	0.75	0.82		6	0.33	0.82		5	0.80	1.30			POST		7	0.00	0.00
10	PRE	4	6	0.00	0.00	8	6	0.17	0.41	7	5	0.00	0.00	3	5	0.00	0.00							
	POST		6	0.00	0.00		6	0.33	0.61		5	0.10	0.22		5	0.00	0.41							
11	PRE	11	6	0.25	0.61	12	6	0.17	0.26	6	5	0.00	0.00	5	6	0.17	0.41							
	POST		5	1.10	1.60		6	0.50	0.84		6	0.83	1.33		6	0.00	0.00							
12	PRE	2	6	0.50	0.84	9	6	1.25	2.82	10	6	0.25	0.42	1	5	0.50	1.12							
	POST		6	1.50	2.81		5	1.20	2.68		6	0.50	1.22		5	0.20	0.45							
TREATMENT EFFECT	PRE			0.44	0.55			0.54	0.67			0.38	0.62			0.28	0.38			PRE			0.49	0.51
	POST			0.78	0.79			0.57	0.46			0.51	0.48			0.27	0.33			POST			0.70	0.57

TABLE D-15

Question-Generating Test, Paper-and-Pencil Measure (Quality Rating) Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMFNT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD		ID		CLASS	N	X̄	SD
1	PRE	10	6	2.95	0.47	1	5	3.82	0.30	9	6	3.02	0.42	2	6	0.34	0.58		13	PRE	1	3	3.00	0.46
	POST		6	3.05	0.68		5	3.12	0.63		6	3.53	0.43		6	0.30	0.48			POST		3	3.00	0.66
2	PRE	6	6	3.58	0.33	5	5	3.12	0.35	11	5	3.26	0.47	12	7	1.34	1.29		13	PRE	2	2	3.05	0.50
	POST		6	3.37	0.36		6	2.88	0.50		5	3.14	0.81		7	2.14	1.14			POST		3	3.03	0.40
3	PRE	1	6	3.23	0.62	10	6	3.08	0.30	2	5	2.82	0.62	9	6	2.08	1.16		13	PRE	9	5	2.48	0.69
	POST		6	3.36	0.51		6	3.23	0.38		6	3.28	0.64		6	2.75	1.48			POST		5	3.38	0.48
4	PRE	3	5	2.72	0.56	7	5	3.20	0.50	8	6	2.53	0.29	4	5	2.74	0.17		13	PRE	10	8	2.92	0.49
	POST		6	2.30	1.43		6	3.18	0.70		6	2.35	1.19		4	2.30	0.90			POST		7	3.07	0.63
5	PRE	5	6	2.23	1.22	11	5	3.20	0.56	12	4	2.95	0.30	6		NO	DATA		14	PRE	5	4	3.52	0.29
	POST		6	2.40	1.24		6	3.42	0.57		5	2.98	0.84							POST		4	3.38	0.69
6	PRE	7	6	3.32	0.58	3	6	3.23	0.48	4	6	2.82	0.94	8	5	2.40	0.90		15	PRE	3	6	2.93	0.76
	POST		6	3.25	0.61		5	3.86	0.96		4	1.88	1.61		5	2.28	0.79			POST		6	3.45	0.61
7	PRE	8	6	2.30	0.36	4	4	3.50	0.41	3	6	2.65	1.42	7	5	3.26	0.57		15	PRE	4	4	3.02	0.25
	POST		6	2.83	0.29		6	2.47	0.49		6	2.73	1.58		5	3.12	0.22			POST		5	2.48	1.48
8	PRE	12	5	2.30	0.94	6	6	3.07	0.47	5	5	3.22	0.60	11	6	2.60	1.70		15	PRE	7	7	2.90	0.57
	POST		6	2.70	0.52		6	3.12	0.67		5	2.62	0.74		7	3.07	0.86			POST		10	2.90	0.66
9	PRE	9	6	2.32	1.45	2	6	3.05	0.42	1	5	3.44	0.39	10	5	3.32	0.36		15	PRE	8	6	2.72	0.61
	POST		6	3.68	0.43		6	3.18	0.33		6	3.07	0.81		5	2.58	1.44			POST		7	3.07	0.55
10	PRE	4	6	3.08	0.71	8		2.73	0.39	7	5	2.96	0.31	3	5	2.90	0.52							
	POST		6	2.75	0.83			1.37	0.33		5	2.62	0.70		5	2.98	1.41							
11	PRE	11	6	3.23	0.55	12	6	3.17	0.47	6	5	2.82	0.30	5	6	3.02	0.56							
	POST		5	3.02	0.89		6	0.33	0.46		6	0.12	0.21		6	2.65	0.36							
12	PRE	2	6	3.07	0.21	9	6	3.00	0.42	10	6	3.07	0.62	1	5	2.88	0.24							
	POST		6	3.12	0.25		5	3.38	0.47		6	3.20	0.34		5	2.42	1.36							
TREATMENT EFFECT	PRE			2.86	0.47			3.18	0.27			2.97	0.27			2.72	0.60			PRE			2.95	0.28
	POST			3.00	0.42			3.19	0.33			2.87	0.46			2.67	0.35			POST			3.08	0.30

TABLE D-16

Question-Generating Test, Oral Measure (Number of Nonpertinent Questions)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	PRE	10	5	1.70	2.64	1	6	1.67	0.26	9	6	0.00	0.00	2	5	0.20	0.45		13	PRE	1	3	1.83	2.31
	POST		3	0.00	0.00		6	0.00	0.00		6	0.00	0.00		5	0.00	0.00			POST		3	3.67	5.92
2	PRE	6	6	0.33	0.82	5	2	0.00	0.00	11	5	0.00	0.00	12	5	0.10	0.22		13	PRE	2	2	0.00	0.00
	POST		4	0.75	0.96		5	0.00	0.00		5	0.30	0.45		3	0.00	0.00			POST		3	0.00	0.00
3	PRE	1	6	0.75	0.88	10	4	0.88	0.63	2	3	0.00	0.00	9	5	0.30	0.45		13	PRE	9	5	0.60	0.82
	POST		6	0.50	1.22		6	0.00	0.00		6	0.17	0.41		6	0.00	0.00			POST		4	0.00	0.00
4	PRE	3	5	0.00	0.00	7	6	0.08	0.20	8	5	0.00	0.00	4	4	0.00	0.00		13	PRE	10	7	0.57	0.61
	POST		6	0.08	0.20		6	0.08	0.20		4	0.00	0.00		4	0.00	0.00			POST		7	0.14	0.24
5	PRE	5	5	0.20	0.45	11	6	0.09	0.11	12	5	0.10	0.22	6		NO	DATA		14	PRE	5	2	0.75	1.06
	POST		6	0.67	1.21		3	0.00	0.00		6	0.00	0.00							POST				
6	PRE	7	4	0.00	0.00	3	4	0.00	0.00	4	3	0.50	0.50	8	4	0.50	0.58		15	PRE	3	5	0.00	0.00
	POST		6	0.58	0.92		5	0.10	0.22		6	0.08	0.20		5	0.20	0.27			POST		5	0.20	0.45
7	PRE	8	6	0.25	0.42	4	2	0.00	0.00	3	3	0.17	0.41	7	5	0.20	0.45		15	PRE	4	3	0.00	0.00
	POST		6	0.08	0.20		4	0.00	0.00		6	0.00	0.00		6	0.17	0.41			POST		5	0.00	0.00
8	PRE	12	4	0.38	0.48	6	5	0.40	0.89	5	5	0.20	0.45	11	5	0.10	0.22		15	PRE	7	9	0.00	0.00
	POST		4	0.00	0.00		5	0.00	0.00		6	0.08	0.20		6	0.00	0.00			POST		10	0.10	0.32
9	PRE	9	5	0.20	0.27	2	5	0.00	0.00	1	6	0.25	0.61	10	5	0.60	1.08		15	PRE	8	5	0.20	0.45
	POST		5	0.10	0.22		6	0.00	0.00		6	0.00	0.00		5	0.00	0.00			POST		7	0.36	0.63
10	PRE	4	5	1.60	2.30	8	5	0.10	0.22	7	6	0.17	0.41	3	6	0.00	0.00							
	POST		4	0.75	1.50		6	0.08	0.20		6	0.75	1.00		6	0.25	0.42							
11	PRE	11	5	0.20	0.45	12	3	1.33	2.31	6	6	0.33	0.82	5	5	0.10	0.22							
	POST		6	0.00	0.00		5	0.80	1.52		6	0.08	0.20		5	0.00	0.00							
12	PRE	2	5	0.10	0.22	9	6	0.25	0.61	10	5	0.30	0.67	1	5	0.40	0.42							
	POST		6	0.42	1.02		5	0.10	0.22		5	0.00	0.00		5	0.00	0.00							
TREATMENT EFFECT	PRE			0.48	0.58			0.30	0.41			0.17	0.16			0.23	0.20			PRE			0.44	0.60
	POST			0.33	0.31			0.10	0.23			0.10	0.16			0.06	0.10			POST			0.56	[illegible].26

TABLE D-17

Question-Generating Test, Oral Measure (Number of Pertinent Questions)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	PRE	10	5	0.60	1.08	1	6	1.75	1.78	9	6	1.58	1.50	2	5	1.00	1.73		13	PRE	1	3	2.17	0.76
	POST		3	0.83	1.44		6	2.67	0.98		5	1.30	1.35		5	1.10	1.14			POST		3	3.67	2.08
2	PRE	6	6	1.08	1.28	5	2	1.50	0.71	11	5	1.00	0.71	12	5	1.10	1.34		13	PRE	2	2	1.00	1.41
	POST		4	1.38	1.60		5	0.60	0.89		5	2.30	1.04		3	0.67	0.58			POST		3	1.33	1.16
3	PRE	1	6	1.17	1.17	10	4	0.62	0.95	2	3	0.33	0.58	9	5	0.70	0.67		13	PRE	9	5	1.40	1.48
	POST		6	1.00	1.14		6	1.83	0.41		6	1.58	1.02		6	2.33	0.98			POST		4	1.62	1.11
4	PRE	3	5	0.00	0.00	7	6	0.67	0.75	8	5	0.40	0.89	4	4	1.25	0.96		13	PRE	10	7	0.50	0.66
	POST		6	1.83	1.84		6	1.42	1.46		4	1.00	1.41		4	1.25	1.26			POST		7	2.36	3.52
5	PRE	5	5	0.20	0.45	11	4	1.25	0.29	12	5	0.70	0.84	6		NO	DATA		14	PRE	5	2	1.00	1.41
	POST		6	0.67	1.62		3	2.47	0.58		6	0.67	1.21							POST				
6	PRE	7	4	1.25	1.26	3	4	1.62	1.89	4	3	1.00	1.32	8	4	0.00	0.00		15	PRE	3	5	1.20	1.30
	POST			2.17	1.33		5	1.40	1.56		6	1.17	1.17		5	0.90	0.74			POST		5	1.00	0.71
7	PRE	8	6	0.67	0.82	4	2	0.50	0.71	3	6	0.67	0.52	7	5	0.90	1.02		15	PRE	4	3	0.33	0.58
	POST		6	1.08	1.11		4	1.62	1.11		6	1.58	1.50		6	1.83	1.60			POST		5	1.30	1.20
8	PRE	12	4	3.65	4.47	6	5	1.20	1.30	5	5	1.10	1.60	11	5	1.30	1.30		15	PRE	7	9	0.33	0.71
	POST		4	1.62	0.95		5	2.00	1.58		6	1.83	1.84		6	1.33	1.03			POST		10	1.10	1.45
9	PRE	9	5	1.70	1.40	2	5	0.50	0.50	1	6	1.92	1.02	10	5	0.60	1.08		15	PRE	8	5	0.80	0.84
	POST		5	2.10	1.02		6	1.34	1.03		6	2.83	1.99		5	2.20	1.60			POST		7	0.86	0.85
10	PRE	4	5	0.00	0.00	8	5	0.40	0.55	7	6	1.08	0.80	3	6	0.83	2.04							
	POST		4	1.00	1.41		6	2.50	0.84		6	2.00	0.71		6	0.58	0.80							
11	PRE	11	5	1.20	1.79	12	3	6.87	5.51	6	6	1.08	1.02	5	5	0.90	1.02							
	POST		6	1.25	1.26		5	1.40	0.96		6	2.08	1.77		5	1.40	1.14							
12	PRE	2	5	2.10	1.82	9	6	1.00	1.67	10	5	0.70	0.98	1	5	1.00	1.06							
	POST		6	1.42	1.24		5	2.40	1.56		5	1.20	1.30		5	0.80	0.84							
TREATMENT	PRE			1.17	1.00			1.49	1.76			0.96	0.46			0.94	0.38			PRE			0.97	0.58
EFFECT	POST			1.36	0.49			1.82	0.64			1.63	0.61			1.31	0.59			POST			1.65	0.94

TABLE D-18

Question-Generating Test, Oral Measure (Quality Rating)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	PRE	10	5	0.34	0.53	1	6	1.15	0.69	9	6	0.95	0.81	2	5	0.60	0.82		13	PRE	1	3	1.17	0.29
	POST		3	0.33	0.58		6	1.25	0.21		5	1.08	0.95		5	0.74	0.70			POST		3	1.13	0.15
2	PRE	6	6	0.95	0.89	5	2	1.50	0.71	11	5	1.30	0.78	12	5	0.64	0.69		13	PRE	2	2	0.60	0.85
	POST		4	0.90	1.04		5	0.50	0.71		5	1.28	0.36		3	1.33	1.16			POST		3	0.67	0.58
3	PRE	1	6	0.73	0.67	10	4	0.55	0.80	2	3	0.33	0.58	9	5	0.60	0.55		13	PRE	9	5	0.78	0.65
	POST		6	0.72	0.66		6	1.13	0.10		6	1.37	0.43		6	1.40	1.34			POST		4	1.10	0.76
4	PRE	3	5	0.00	0.00	7	6	0.73	0.84	8	5	0.34	0.76	4	4	1.10	0.80		13	PRE	10	7	0.36	0.48
	POST		6	0.75	0.61		6	0.77	0.70		4	0.58	0.68		4	1.50	1.22			POST		7	0.96	0.68
5	PRE	5	5	0.26	0.58	11	4	1.12	0.25	12	5	0.60	0.55	6		NO	DATA		14	PRE	5	2	0.50	0.71
	POST		6	0.22	0.53		3	1.33	0.58		6	0.48	0.75							POST				
6	PRE	7	4	1.20	0.85	3	4	0.55	0.64	4	3	0.63	0.51	8	4	0.00	0.00		15	PRE	3	5	0.86	0.86
	POST		6	1.03	0.54		5	0.66	0.62		6	0.80	0.65		5	1.00	0.71			POST		5	0.90	0.55
7	PRE	8	6	0.58	0.80	4	2	1.00	1.41	3	6	0.67	0.61	7	5	0.70	0.84		16	PRE	4	3	0.23	0.40
	POST		6	0.92	0.80		4	0.88	0.63		6	0.97	0.81		6	0.87	0.72			POST		5	1.06	0.77
8	PRE	12	4	0.62	0.48	6	5	0.92	0.90	5	5	0.50	0.71	11	5	0.82	0.76		15	PRE	7	9	0.28	0.56
	POST		4	1.32	0.46		5	0.94	0.56		6	0.78	0.61		6	1.38	0.78			POST		10	0.74	0.81
9	PRE	9	5	0.98	0.70	2	5	0.90	0.89	1	6	1.05	0.56	10	5	0.90	0.89		15	PRE	8	5	1.14	1.05
	POST		5	1.06	0.34		6	1.30	0.87		6	1.02	0.30		5	1.18	0.70			POST		7	1.01	0.78
10	PRE	4	5	0.00	0.00	8	5	0.50	0.71	7	6	0.92	0.66	3	6	0.20	0.49							
	POST		4	0.65	0.76		6	1.22	0.23		6	1.28	0.53		6	0.42	0.49							
11	PRE	11	5	0.64	0.92	12	3	5.37	8.34	6	6	0.75	0.76	5	5	0.70	0.84							
	POST		6	1.82	0.79		5	1.10	0.74		6	1.05	0.65		5	1.06	0.72							
12	PRE	2	5	1.12	0.76	9	6	0.45	0.70	10	5	0.30	0.45	1	5	0.70	0.67							
	POST		6	0.93	0.75		5	0.92	0.54		5	0.70	0.67		5	0.84	0.85							
REATMENT FFECT	PRE			0.62	0.41			1.23	1.34			0.69	0.31			0.63	0.30			PRE			0.66	0.35
	POST			o.80	0.31			1.00	0.27			0.95	0.29			1.07	0.33			POST			0.95	0.17

TABLE D-19

Word Association Scale (Attitude toward Balance of Nature)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	PRE	10	6	55.83	9.56	1	6	56.50	5.24	9	6	51.67	3.78	2	6	55.67	4.59		13	PRE	1	3	56.00	10.58
	POST		6	58.33	13.67		5	59.40	7.23		6	58.17	8.70		6	56.17	7.41			POST		3	60.00	4.58
2	PRE	6	6	52.33	3.56	5	6	52.67	5.57	11	6	61.50	7.42	12	7	46.86	15.44		13	PRE	2	3	49.33	9.02
	POST		5	57.60	6.58		6	57.67	8.91		5	53.60	9.79		6	60.00	11.19			POST		2	57.50	6.36
3	PRE	1	6	62.17	3.19	10	6	49.00	15.07	2	5	53.40	6.80	9	6	47.17	19.03		13	PRE	9	5	51.80	10.43
	POST		6	49.17	6.51		6	56.50	15.72		6	53.67	20.74		6	52.00	13.27			POST		5	49.40	6.39
4	PRE	3	6	53.50	10.78	7	6	54.50	5.39	8	5	46.80	8.70	4	5	56.40	7.89		13	PRE	10	8	47.00	10.93
	POST		6	52.50	12.31		6	59.50	7.40		4	57.75	6.50		4	34.25	19.53			POST		6	48.33	11.62
5	PRE	5	6	50.00	11.03	11	6	54.67	5.57	12	6	53.17	15.97	6		NO	DATA		14	PRE	5	3	47.67	7.09
	POST		5	56.20	10.18		6	51.17	13.32		5	54.80	9.23							POST		2	56.00	2.83
6	PRE	7	5	56.80	10.94	3	6	55.33	3.20	4	5	59.00	11.36	8	5	49.80	17.21		15	PRE	3	6	59.67	10.46
	POST		5	54.80	9.15		3	62.67	11.02		4	57.50	15.00		2	65.50	6.36			POST		6	58.50	13.31
7	PRE	8	6	53.67	7.31	4	5	50.60	11.48	3	6	55.33	11.91	7	4	64.75	3.86		15	PRE	4	4	48.75	9.81
	POST		4	54.00	7.62		5	62.20	6.26		6	54.50	19.15		6	60.83	10.07			POST		5	50.20	20.89
8	PRE	12	6	56.50	3.08	6	4	55.75	4.79	5	5	53.00	7.31	11	6	54.17	5.23		15	PRE	7	10	56.20	4.54
	POST		5	56.00	8.06		5	43.40	9.74		5	59.00	10.46		6	52.83	15.12			POST		9	56.22	7.03
9	PRE	9	6	49.17	6.34	2	6	54.00	5.44	1	6	60.33	9.11	10	4	60.00	11.80		15	PRE	8	7	50.14	7.54
	POST		6	61.17	11.80		6	56.83	8.75		6	59.83	7.99		5	63.80	6.94			POST		7	53.00	5.94
10	PRE	4	6	57.83	8.75	8	6	55.33	8.36	7	6	53.83	3.76	3	4	45.50	3.11							
	POST		6	54.17	10.92		6	62.00	6.51		5	65.40	6.62		6	53.00	10.55							
11	PRE	11	6	50.17	6.55	12	5	54.80	18.89	6	6	53.33	8.33	5	6	46.00	7.24							
	POST		6	55.00	14.67		6	57.00	17.49		6	56.33	11.64		6	58.17	8.93							
12	PRE	2	6	54.50	3.51	9	6	59.83	8.91	10	6	52.33	7.66	1	6	52.17	11.27							
	POST		6	58.50	6.38		4	63.00	10.10		6	62.17	10.61		6	56.67	12.39							
TREATMENT EFFECT	PRE			54.37	3.75			54.41	2.77			54.47	4.08			52.59	6.27			PRE			51.84	4.43
	POST			55.62	3.13			57.61	5.62			57.72	3.56			55.74	8.38			POST			54.35	4.26

TABLE D-20

Word Association Scale (Attitude toward Ecology)
Study I Descriptive Statistics

ECOLOGY TEACHER ID		PROBING AND REDIRECTION TREATMENT CLASS	N	$\bar{X}$	SD	NO PROBING AND REDIRECTION TREATMENT CLASS	N	$\bar{X}$	SD	FILLER ACTIVITY TREATMENT CLASS	N	$\bar{X}$	SD	ART ACTIVITY TREATMENT I CLASS	N	$\bar{X}$	SD	
1	PRE	10	6	53.00	14.42	1	6	53.67	12.64	9	6	55.67	4.41	2	6	54.00	11.10	
	POST		6	58.83	16.14		5	64.80	5.40		6	60.33	10.97		6	61.17	8.68	
2	PRE	6	6	54.67	9.42	5	6	58.50	11.41	11	6	54.33	18.53	12	7	51.57	19.45	
	POST		5	60.40	7.99		6	53.33	23.22		5	55.20	10.47		6	66.67	6.80	
3	PRE	1	6	64.50	5.99	10	6	41.83	13.35	2	5	50.60	5.73	9	6	42.33	15.31	
	POST		6	52.33	8.82		6	50.33	14.95		6	62.67	10.60		6	54.83	14.74	
4	PRE	3	6	52.50	10.56	7	6	56.00	12.03	8	5	50.00	8.09	4	5	43.40	12.86	
	POST		6	56.00	11.14		6	65.33	5.54		4	63.75	5.80		4	61.25	7.63	
5	PRE	5	6	46.83	7.31	11	6	51.83	18.63	12	6	55.17	8.98	6		NO	DATA	
	POST		5	49.40	22.47		6	61.83	12.78		5	60.60	9.29					
6	PRE	7	5	56.80	7.98	3	6	53.67	3.88	4	5	61.20	12.24	8	5	61.80	6.06	
	POST		5	58.00	12.90		3	66.33	3.21		4	61.25	10.31		2	67.00	4.24	
7	PRE	8	6	58.50	11.20	4	5	41.60	12.42	3	6	57.67	11.71	7	4	56.50	12.40	
	POST		4	61.00	8.76		5	55.40	17.17		6	55.33	15.74		6	68.67	2.42	
8	PRE	12	6	57.00	1.79	6	4	58.00	8.04	5	5	49.40	7.77	11	6	60.00	8.20	
	POST		5	59.60	8.08		5	60.40	11.84		5	58.40	12.01		6	57.83	12.42	
9	PRE	9	6	53.67	15.81	2	6	53.00	10.97	1	6	58.00	6.32	10	4	54.75	24.30	
	POST		6	65.33	11.43		6	64.17	7.52		6	63.00	7.27		5	65.40	6.39	
10	PRE	4	6	54.50	7.66	8	6	54.83	11.21	7	6	50.33	10.17	3	4	40.50	5.51	
	POST		6	57.33	11.32		6	65.33	5.16		5	66.20	5.50		6	45.33	11.60	
11	PRE	11	6	59.67	8.41	12	5	64.20	5.85	6	6	60.50	8.31	5	6	60.50	11.45	
	POST		6	64.67	2.68		6	64.33	9.77		6	64.33	10.23		6	61.50	9.25	
12	PRE	2	6	59.17	5.98	9	6	55.50	11.54	10	6	54.33	11.18	1	6	53.33	14.56	
	POST		6	58.00	14.70		4	65.00	9.35		6	61.67	13.09		6	59.67	12.27	
TREATMENT EFFECT	PRE			55.90	4.45			53.55	6.41			54.76	4.08			52.61	7.49	
	POST			58.41	4.52			61.38	5.40			61.06	3.89			60.84	6.65	

WRITTEN EXERCISE TEACHER ID		WRITTEN EXERCISE TREATMENT CLASS	N	$\bar{X}$	SD
13	PRE	1	3	34.00	21.38
	POST		3	39.33	24.34
13	PRE	2	3	59.00	4.36
	POST		2	67.00	4.24
13	PRE	9	5	51.80	20.38
	POST		5	69.60	0.89
13	PRE	10	8	39.13	15.00
	POST		6	57.83	14.09
14	PRE	5	6	50.33	17.67
	POST		2	68.50	2.12
15	PRE	3	6	62.17	6.46
	POST		6	64.00	6.66
15	PRE	4	4	50.75	15.44
	POST		5	53.80	25.06
15	PRE	7	10	63.20	6.30
	POST		9	63.56	7.47
15	PRE	8	7	54.14	10.42
	POST		7	60.71	12.23
	PRE			51.61	9.84
	POST			60.48	9.43

TABLE D-21

Word Association Scale (Attitude toward Wolves)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD		ID		CLASS	N	X̄	SD
1	PRE	10	6	42.17	6.43	1	6	43.17	11.72	9	6	46.50	9.54	2	6	40.00	6.29		13	PRE	1	3	33.33	5.51
	POST		6	56.33	10.88		5	55.00	6.56		6	50.33	12.45		6	47.17	10.34			POST		3	44.33	5.69
2	PRE	6	6	44.17	6.21	5	6	47.17	9.75	11	6	47.17	13.42	12	7	45.14	7.36		13	PRE	2	3	47.00	16.37
	POST		5	51.80	8.07		6	48.83	11.46		5	53.80	13.70		6	53.83	8.21			POST		2	41.50	2.12
3	PRE	1	6	54.67	16.27	10	6	43.66	8.64	2	5	37.20	7.79	9	6	43.50	9.38		13	PRE	9	5	47.00	17.55
	POST		6	51.83	10.76		6	48.67	11.09		6	36.50	12.37		6	44.00	12.84			POST		5	46.00	11.81
4	PRE	3	6	50.17	15.94	7	6	46.67	5.24	8	5	39.20	8.53	4	5	53.60	12.50		13	PRE	10	8	41.88	10.88
	POST		6	54.50	7.89		6	57.17	11.21		4	55.00	13.56		4	43.50	18.30			POST		6	51.33	12.45
5	PRE	5	6	35.33	6.22	11	6	48.67	12.19	12	6	39.17	13.89	6		NO	DATA		14	PRE	5	3	37.33	7.23
	POST		5	46.00	8.46		6	50.50	15.74		5	38.40	9.91							POST		2	54.50	2.12
6	PRE	7	5	46.20	11.34	3	6	50.33	7.17	4	5	40.00	17.36	8	5	35.20	15.98		15	PRE	3	6	53.50	4.51
	POST		5	47.00	6.56		3	63.33	3.21		4	42.75	7.85		2	34.50	26.16			POST		6	56.50	7.45
7	PRE	8	6	41.33	4.59	4	5	51.00	18.34	3	6	52.33	5.61	7	4	50.75	9.60		15	PRE	4	5	50.50	7.55
	POST		4	58.50	8.74		5	51.40	10.04		6	53.33	11.02		6	50.67	13.44			POST		5	58.40	14.26
8	PRE	12	6	43.33	8.66	6	4	49.50	15.50	5	5	41.60	10.24	11	6	51.83	7.91		15	PRE	7	10	44.90	9.24
	POST		5	54.40	88.80		5	45.20	10.33		5	52.40	11.01		6	56.50	12.44			POST		9	49.89	10.02
9	PRE	9	6	51.33	10.35	2	6	42.50	4.14	1	6	42.17	15.90	10	4	57.00	1.41		15	PRE	8	7	44.43	7.61
	POST		6	57.33	8.38		6	50.33	8.78		6	54.50	7.06		5	55.20	13.52			POST		7	55.43	8.81
10	PRE	4	6	44.33	13.71	8	6	40.33	16.91	7	6	44.17	8.35	3	4	38.75	11.93							
	POST		6	47.67	11.45		6	57.83	12.11		5	59.40	7.67		6	43.00	7.54							
11	PRE	11	6	49.33	6.44	12	5	45.40	12.44	6	6	38.67	17.56	5	6	42.67	15.87							
	POST		6	47.17	7.08		6	56.17	12.02		6	56.67	10.88		6	42.17	14.82							
12	PRE	2	6	47.00	7.80	9	6	38.50	14.57	10	6	44.67	17.08	1	6	44.83	12.64							
	POST		6	50.50	7.87		4	39.75	24.50		6	58.00	11.40		6	51.33	11.40							
TREATMENT EFFECT	PRE			45.14	4.41			45.49	4.00			42.73	4.40			45.76	6.78			PRE			44.43	6.25
	POST			52.75	4.30			52.01	6.31			50.84	7.54			47.44	6.72			POST			50.87	5.89

TABLE D-22

Word Association Scale (Attitude toward Air Pollution)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD		ID		CLASS	N	X̄	SD
1	PRE	10	6	55.17	5.60	1	6	60.00	5.25	9	6	57.67	4.27	2	6	63.00	4.52		13	PRE	1	3	51.67	7.77
	POST		6	62.83	3.92		5	62.20	5.22		6	56.00	6.20		6	62.33	3.44			POST		3	58.00	0.00
2	PRE	6	6	55.83	11.07	5	6	62.50	5.92	11	6	59.17	4.22	12	7	58.14	7.63		13	PRE	2	3	58.00	0.00
	POST		5	64.20	3.90		6	58.50	6.69		5	58.00	0.00		6	60.83	4.67			POST		2	59.50	2.12
3	PRE	1	6	54.67	16.27	10	6	49.33	9.54	2	5	59.40	14.03	9	6	56.00	6.20		13	PRE	9	5	58.00	0.00
	POST		6	62.00	5.25		6	49.33	12.16		6	61.50	6.25		6	55.33	8.52			POST		5	58.00	0.00
4	PRE	3	6	50.00	12.98	7	6	57.67	2.25	8	[illegible]	51.60	7.54	4	5	56.40	15.98		13	PRE	10	8	54.30	8.06
	POST		6	61.67	2.94		6	60.00	4.90		4	60.75	3.77		4	56.25	2.87			POST		6	57.33	5.16
5	PRE	5	6	55.83	12.86	11	6	60.17	2.99	12	6	55.83	7.63	6		NO	DATA		14	PRE	5	3	61.33	3.06
	POST		5	60.80	6.26		6	61.50	4.81		5	60.40	6.84							POST		2	66.00	2.83
6	PRE	7	5	62.60	5.27	3	6	60.67	5.79	4	5	58.00	10.17	8	5	59.40	3.58		15	PRE	3	6	56.33	6.65
	POST		5	58.00	4.24		3	60.67	0.58		4	54.00	5.66		2	59.00	2.83			POST		6	55.17	5.67
7	PRE	8	6	56.67	4.63	4	5	56.00	11.58	3	6	64.00	4.43	7	4	57.75	0.50		15	PRE	4	4	63.25	6.18
	POST		4	58.00	8.48		5	60.40	3.29		6	64.00	5.37		6	58.00	0.00			POST		5	54.60	18.43
8	PRE	12	6	58.83	4.58	6	4	50.50	12.61	5	5	61.20	3.96	11	6	56.00	9.57		15	PRE	7	10	62.40	3.89
	POST		5	60.60	2.61		5	61.40	3.13		5	52.40	12.52		4	51.33	11.86			POST		9	59.22	2.73
9	PRE	9	6	62.00	4.90	2	6	63.33	4.08	1	6	62.00	3.16	10	4	46.50	17.00		15	PRE	8	7	60.19	7.03
	POST		6	63.00	5.90		6	60.83	3.13		6	55.17	13.56		5	59.60	8.17			POST		7	56.29	9.81
10	PRE	4	6	60.00	5.73	8	6	60.00	2.45	7	6	57.33	6.28	3	4	59.00	4.40							
	POST		6	58.50	6.89		6	58.83	2.56		5	56.00	9.82		6	57.33	4.13							
11	PRE	11	6	58.00	6.60	12	5	60.40	3.29	6	6	61.50	3.89	5	6	56.00	12.51							
	POST		6	56.33	5.99		6	59.00	2.45		6	63.67	3.88		6	58.50	4.85							
12	PRE	2	6	62.50	4.14	9	6	58.67	4.68	10	6	56.17	4.49	1	6	50.67	9.18							
	POST		6	57.50	4.18		4	59.50	8.00		6	55.67	3.67		6	60.17	3.82							
TREATMENT EFFECT	PRE			57.67	3.76			58.27	4.36			58.65	3.33			56.26	4.42			PRE			58.39	3.83
	POST			60.29	2.55			59.35	3.36			58.13	3.84			58.06	3.01			POST			58.23	3.36

TABLE D-23

Word Association Scale (Attitude toward Alligators)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD		ID		CLASS	N	X̄	SD
1	PRE POST	10	6 6	37.67 48.50	10.78 10.25	1	6 5	36.33 47.20	10.84 10.18	9	6 6	43.00 45.67	7.24 13.71	2	6 6	37.50 47.00	7.23 9.26		13	PRE POST	1	3	34.67 42.00	3.21 4.36
2	PRE POST	6	6 5	41.00 49.20	10.35 10.35	5	6 6	43.50 44.33	5.58 1.51	11	6 5	37.67 51.80	13.71 6.30	12	7 6	34.33 40.00	12.43 13.05		13	PRE POST	2	3 2	45.67 57.00	10.41 11.31
3	PRE POST	1	6 6	33.67 37.00	10.33 11.40	10	6 6	35.67 45.83	8.19 12.42	2	5 6	35.60 33.33	8.85 12.45	9	6 6	37.83 44.50	12.89 12.03		13	PRE POST	9	5 5	41.80 48.20	6.94 12.36
4	PRE POST	3	6 6	36.50 49.83	14.87 6.85	7	6 6	43.17 57.50	12.37 11.11	8	5 4	31.80 42.25	7.66 19.60	4	5 4	37.40 46.50	8.85 16.38		13	PRE POST	10	8 6	35.38 46.00	11.99 7.54
5	PRE POST	5	6 5	34.50 40.20	12.58 7.98	11	6 6	45.17 52.33	9.41 5.92	12	6 5	33.33 38.60	19.78 12.86	6		NO	DATA		14	PRE POST	5	3 2	33.00 48.50	10.44 2.12
6	PRE POST	7	5 5	40.60 44.20	21.27 4.76	3	6 3	38.50 51.67	7.23 5.03	4	5 4	36.60 34.25	13.89 21.31	8	5 2	39.80 41.50	16.04 13.44		15	PRE POST	3	6 6	45.33 51.00	8.31 6.26
7	PRE POST	8	6 4	40.67 57.00	4.41 8.76	4	5 5	43.00 49.00	11.83 9.08	3	6 6	40.17 42.17	10.80 14.66	7	4 6	42.00 34.67	13.22 14.11		15	PRE POST	4	4 5	41.00 53.40	9.13 11.46
8	PRE POST	12	6 5	40.00 49.40	8.49 4.67	6	4 5	48.75 37.80	7.68 8.73	5	5 5	33.60 47.80	14.93 10.80	11	6 6	44.33 48.17	10.78 9.30		15	PRE POST	7	10 9	40.30 45.78	9.36 8.84
9	PRE POST	9	6 6	47.17 51.67	8.38 11.81	2	6 6	40.50 50.50	5.06 11.18	1	6 6	42.67 52.50	16.29 10.43	10	4 5	50.50 51.20	13.33 14.65		15	PRE POST	8	7 7	38.14 44.57	7.80 4.69
10	PRE POST	4	6	37.00 41.83	11.14 8.89	8	6 6	39.50 50.67	12.41 13.72	7	6 5	44.67 56.20	9.85 11.65	3	4 6	28.75 39.00	6.99 13.65							
11	PRE POST	11	6 6	38.50 53.67	11.67 9.44	12	5 6	40.20 52.67	14.70 11.20	6	6 6	36.67 50.17	18.16 12.58	5	6 6	43.17 45.17	16.34 14.77							
12	PRE POST	2	6 6	41.83 44.33	7.83 6.31	9	6 4	27.33 37.75	19.34 23.56	10	6 6	37.83 44.17	6.43 8.84	1	6 6	39.67 44.67	10.15 15.06							
TREATMENT EFFECT	PRE POST			39.09 47.24	3.64 5.83			40.13 48.10	5.48 5.93			37.80 44.91	4.10 7.21			39.58 43.85	5.63 4.70			PRE POST			39.47 48.49	4.54 4.66

TABLE D-24

Word Association Scale (Attitude toward Water Pollution)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	PRE	10	6	52.17	11.91	1	6	59.50	4.97	9	6	56.33	5.85	2	6	63.67	3.88		13	PRE	1	3	49.33	7.77
	POST		6	61.00	3.29		5	61.60	5.37		6	55.33	10.25		6	63.33	5.28			POST		3	58.00	0.00
2	PRE	6	6	57.17	5.15	5	6	61.00	6.29	11	6	60.50	3.99	12	7	56.43	10.36		13	PRE	2	3	58.00	0.00
	POST		5	64.80	4.44		6	57.67	6.59		5	58.00	0.00		6	61.00	5.02			POST		2	59.50	2.12
3	PRE	1	6	56.33	14.28	10	6	45.67	11.94	2	5	58.40	8.76	9	6	47.83	13.26		13	PRE	9	5	58.60	1.34
	POST		6	61.50	5.86		6	49.83	12.14		6	61.83	6.15		6	53.83	7.49			POST		5	58.00	0.00
4	PRE	3	6	51.00	14.83	7	6	56.17	5.49	8	5	52.80	7.92	4	5	48.20	15.53		13	PRE	10	8	53.25	8.22
	POST		6	58.67	4.46		6	60.00	5.06		4	60.25	4.50		4	51.25	11.59			POST		6	55.50	6.95
5	PRE	5	6	54.50	11.42	11	6	59.50	2.35	12	6	52.33	10.71	6		NO	DATA		14	PRE	5	3	62.33	1.53
	POST		5	58.80	9.26		6	63.50	5.50		5	58.00	6.00							POST		2	66.00	2.83
6	PRE	7	5	62.60	5.27	3	6	61.67	3.83	4	5	59.20	6.91	8	5	58.40	2.19		15	PRE	3	6	59.67	3.01
	POST		5	57.00	5.10		3	61.67	4.04		4	55.75	2.87		2	58.00	0.00			POST		6	58.33	2.58
7	PRE	8	6	59.33	2.80	4	5	52.20	17.06	3	6	60.83	5.15	7	4	59.75	2.87		15	PRE	4	4	66.25	5.68
	POST		4	59.00	3.46		5	61.60	5.37		6	64.00	5.37		6	57.50	1.22			POST		5	60.80	6.57
8	PRE	12	6	57.50	5.50	6	4	54.25	11.84	5	5	62.80	6.61	11	6	56.17	7.39		15	PRE	7	10	59.90	10.22
	POST		5	60.60	2.61		5	61.00	3.74		5	52.40	12.52		6	53.33	7.23			POST		9	56.11	10.98
9	PRE	9	6	59.50	7.04	2	6	59.33	3.93	1	6	61.17	6.21	10	4	57.00	6.63		15	PRE	8	7	59.29	6.78
	POST		6	62.50	6.50		6	60.00	3.10		6	55.50	17.01		5	59.60	8.17			POST		7	60.43	6.58
10	PRE	4	6	58.17	1.94	8	6	59.00	1.67	7	6	57.33	6.28	3	4	59.00	7.87							
	POST		6	54.83	9.11		6	58.00	3.79		5	58.60	6.15		6	55.00	9.92							
11	PRE	11	6	55.33	4.50	12	5	59.80	2.68	6	6	61.33	4.89	5	6	54.67	9.67							
	POST		6	58.33	7.81		6	59.00	2.45		6	63.33	3.98		6	55.83	10.68							
12	PRE	2	6	61.00	6.42	9	6	52.83	7.05	10	6	57.00	2.45	1	6	55.83	5.95							
	POST		6	57.83	4.12		4	57.25	1.50		6	56.67	2.42		6	60.17	3.37							
TREATMENT EFFECT	PRE			57.05	3.43			56.74	4.71			58.33	3.33			56.08	4.67			PRE			58.51	4.88
	POST			59.57	2.67			59.26	3.52			58.30	3.50			57.17	3.68			POST			59.18	3.11

TABLE D-25

Gall-Crown Discussion Attitude Scale (Attitude toward Thought Questions)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	PRE	10	6	24.83	7.02	1	6	30.50	6.22	9	6	27.33	8.33	2	6	30.00	6.57		13	PRE	1	3	26.00	7.55
	POST		6	25.00	4.24		6	33.33	6.28		6	25.17	7.47		6	34.67	6.19			POST		3	24.67	10.02
2	PRE	6	6	27.00	4.38	5	6	30.00	3.03	11	6	32.33	3.23	12	7	30.29	8.67		13	PRE	2	3	32.67	6.66
	POST		5	26.60	4.56		5	30.00	2.82		5	28.60	4.77		6	30.50	5.47			POST		3	28.67	3.79
3	PRE	1	6	31.50	4.97	10	6	27.83	3.55	2	5	30.80	3.11	9	6	31.17	5.85		13	PRE	9	5	28.60	4.34
	POST		6	33.83	5.38		4	33.25	8.06		6	30.83	5.08		4	30.25	6.70			POST		5	31.20	5.81
4	PRE	3	6	27.33	3.01	7	6	25.00	3.52	8	6	29.00	3.10	4	5	31.80	3.42		13	PRE	10	7	26.86	6.99
	POST		6	30.00	8.10		6	30.67	6.44		5	29.10	2.61		4	32.00	3.74			POST		8	31.00	6.16
5	PRE	5	6	28.17	3.31	11	6	29.00	4.65	12	5	31.60	5.59	6		NO	DATA		14	PRE	5	4	24.25	7.59
	POST		6	29.83	8.45		6	29.17	6.21		5	30.20	4.82							POST		5	29.40	5.50
6	PRE	7	6	29.50	3.62	3	6	27.00	2.61	4	6	24.83	6.65	8	5	31.80	6.61		15	PRE	3	6	23.33	4.37
	POST		6	31.67	3.56		5	29.20	4.66		4	27.50	3.51		5	33.20	3.96			POST		4	22.25	6.80
7	PRE	8	6	27.17	7.39	4	4	27.50	3.87	3	6	24.83	5.67	7	5	29.20	3.11		15	PRE	4	5	26.20	6.94
	POST		6	31.17	7.91		5	25.60	5.59		6	29.33	9.79		5	28.20	6.30			POST		5	30.00	9.62
8	PRE	12	6	30.17	6.18	6	6	30.83	6.79	5	6	23.33	3.93	11	7	26.14	2.79		15	PRE	7	9	30.89	5.95
	POST		5	28.80	3.90		6	33.67	5.24		4	30.06	1.71		7	28.57	2.82			POST		9	30.11	6.70
9	PRE	9	6	29.50	3.56	2	6	34.00	3.52	1	6	27.67	6.28	10	5	28.20	5.17		15	PRE	8	7	29.71	3.86
	POST		6	30.00	8.53		6	37.83	3.19		6	34.83	6.24		6	28.66	6.59			POST		8	30.13	4.73
10	PRE	4	6	27.33	4.84	8	6	30.50	6.03	7	6	28.33	2.07	3	6	26.50	2.88							
	POST		5	27.60	3.65		4	38.25	4.57		6	27.67	6.77		5	25.80	7.40							
11	PRE	11	6	29.00	4.15	12	5	29.20	7.79	6	5	30.40	3.78	5	6	27.00	7.64							
	POST		4	35.00	6.48		5	28.20	6.83		6	35.17	5.85		6	28.67	4.89							
12	PRE	2	6	33.17	2.64	9	5	32.33	2.80	10	5	26.17	1.17	1	6	27.33	4.18							
	POST		4	35.17	4.49		5	29.67	6.02		6	29.50	2.59		6	33.17	5.49							
TREATMENT EFFECT	PRE			28.57	2.41			29.47	2.45			28.05	2.90			29.04	2.12			PRE			27.61	3.09
	POST			31.56	2.93			31.57	3.61			29.87	2.84			30.33	2.67			POST			28.60	3.07

TABLE D-26

Gall-Crown Discussion Scale (Attitude toward Discussion)
Study I Descriptive Statistics

OLOGY ACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
D		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD		ID		CLASS	N	X̄	SD
	PRE DELAY	10	6 6	47.33 47.00	10.61 4.29	1	6 6	60.00 60.50	10.55 9.18	9	6 6	53.83 45.67	8.11 11.81	2	6 6	61.33 60.17	7.55 10.01		13	PRE DELAY	1	3 3	56.33 51.00	5.51 9.54
	PRE DELAY	6	6 5	53.00 47.60	4.82 5.94	5	6 5	58.33 54.40	2.66 3.44	11	6 5	54.33 55.20	5.75 3.35	12	7 6	56.57 52.67	10.24 10.53		13	PRE DELAY	2	3 3	61.00 56.33	7.21 8.39
	PRE DELAY	1	6 6	62.33 61.17	2.50 11.58	10	6 4	51.67 56.75	8.02 5.62	2	5 6	60.20 59.33	8.87 11.11	9	6 4	55.83 51.00	7.78 6.22		13	PRE DELAY	9	5 5	55.20 54.20	5.26 8.17
	PRE DELAY	3	6 6	47.83 50.33	6.01 5.32	7	6 6	50.67 51.67	8.76 7.86	8	6 5	55.33 57.20	8.10 7.36	4	5 11	55.20 51.00	8.70 [illegible]		13	PRE DELAY	10	7 8	48.00 56.00	12.73 10.01
	PRE DELAY	5	6 6	54.67 54.17	2.50 9.15	11	6 6	52.83 54.50	9.60 9.98	12	5 5	58.20 54.20	9.36 7.85	6		NO	DATA		14	PRE DELAY	5	4 5	53.50 53.80	3.87 2.28
	PRE DELAY	7	6 6	53.33 51.83	8.14 10.57	3	6 5	53.17 55.40	5.67 4.83	4	6 4	45.83 46.50	9.33 9.11	8	5 5	55.20 58.40	8.20 11.42		15	PRE DELAY	3	6 4	47.50 47.25	6.89 12.09
	PRE DELAY	8	6 6	54.50 58.67	13.03 9.48	4	4 5	46.75 52.80	6.40 2.59	3	6 6	46.83 52.33	5.67 10.01	7	5 5	54.00 53.20	8.60 11.82		15	PRE DELAY	4	5 5	54.20 53.40	9.78 10.43
	PRE DELAY	12	6 5	58.00 50.60	6.87 8.05	6	6 6	57.50 58.17	8.50 10.61	5	6 4	51.17 55.00	4.26 5.03	11	7 7	49.43 52.71	4.58 2.75		15	PRE DELAY	7	9 9	55.89 54.00	8.03 9.77
	PRE DELAY	9	6 6	53.50 52.00	7.12 12.46	2	6 6	64.50 65.50	3.45 6.35	1	6 6	59.83 65.67	3.19 8.21	10	5 6	51.20 54.67	6.72 9.81		15	PRE DELAY	8	7 8	59.86 57.25	59.93 6.54
	PRE DELAY	4	6 5	50.33 52.60	6.35 2.70	8	6 4	54.83 66.75	13.82 7.63	7	6 6	54.50 51.67	5.24 9.67	3	6 5	50.17 44.60	10.01 14.42			PRE DELAY				
	PRE DELAY	11	6 4	53.00 65.75	6.93 4.27	12	5 5	55.80 54.00	12.40 7.38	6	5 6	57.20 59.50	6.98 7.53	5	6 6	53.83 56.33	8.04 8.04			PRE DELAY				
	PRE DELAY	2	6 6	63.83 65.50	5.85 5.65	9	6 6	59.67 55.67	5.13 12.29	10	6 6	48.83 52.50	2.40 3.36	1	6 6	52.83 60.17	8.16 9.21			PRE DELAY				
TMENT CT	PRE DELAY			54.30 57.68	[illegible] 5.86			55.47 57.13	4.85 4.85			53.84 54.56	4.82 5.56			54.14 54.08	3.34 4.60			PRE DELAY			54.61 53.69	4.59 3.04

TABLE D-27

Ecology Unit Opinions (Attitude Toward Peers)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ANT ACTIVITY TREATMENT 1					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	POST	10	6	12.00	2.83	1	5	16.20	2.59	9	6	14.67	3.67	2	6	18.50	1.76		13	POST	1	3	18.33	1.53
2	POST	6	5	12.40	5.19	5	6	10.00	2.76	11	5	14.80	2.86	12	7	14.86	1.67		13	POST	2	3	18.67	0.58
3	POST	1	6	16.83	1.94	10	6	15.00	2.76	2	6	18.83	1.60	9	6	13.67	5.39		13	POST	9	5	15.80	1.79
4	POST	3	6	12.33	2.80	7	6	17.83	2.48	8	6	14.17	5.19	4	5	17.20	2.95		13	POST	10	7	16.00	2.52
5	POST	5	5	17.00	2.45	11	6	14.00	5.37	12	5	16.40	3.81	6		NO	DATA		14	POST	5	4	13.00	3.46
6	POST	7	6	18.00	1.55	3	5	15.80	2.95	4	6	13.50	2.35	8	4	14.75	1.50		15	POST	3	6	15.83	0.75
7	POST	8	6	17.17	1.47	4	6	16.33	2.58	3	5	16.80	3.49	7	5	18.20	2.05		15	POST	4	5	16.40	4.39
8	POST	12	6	19.67	0.52	6	6	17.17	3.49	5	4	18.50	2.38	11	7	14.14	2.67		15	POST	7	10	17.60	2.12
9	POST	9	6	16.50	4.13	2	6	19.17	0.98	1	5	18.20	1.64	10	5	18.60	1.95		15	POST	8	7	12.43	3.41
1	POST	4	6	14.83	3.71	8	6	18.67	2.16	7	4	17.25	1.26	3	6	15.00	4.20							
1	POST	11	6	15.50	3.45	12	6	16.50	2.59	6	6	18.33	1.88	5	6	18.00	2.10							
1	POST	2	6	18.33	1.75	9	5	17.00	2.00	10	6	15.50	3.40	1	5	15.20	5.45							
EATMENT ECT	POST			15.88	2.52			16.14	2.41			16.41	1.86			16.19	1.91			POST			16.00	2.15

TABLE D-28

Ecology Unit Opinions (Attitude Toward Ecology Teacher)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	POST	10	6	54.67	13.00	1	5	60.00	2.92	9	6	58.67	5.75	2	6	61.50	1.76		13	POST	1	3	61.33	4.62
2	POST	6	5	49.60	12.82	5	6	55.17	10.74	11	5	49.20	12.60	12	7	51.00	11.80		13	POST	2	3	62.67	2.31
3	POST	1	6	57.83	5.98	10	6	52.00	10.08	2	6	60.83	3.25	9	6	41.17	13.51		13	POST	9	5	57.60	5.22
4	POST	3	6	54.00	5.80	7	6	61.50	3.33	8	6	50.83	8.11	4	5	54.60	7.77		13	POST	10	7	52.29	11.91
5	POST	5	5	57.80	7.40	11	6	56.17	10.61	12	5	51.80	12.01	6		NO	DATA		14	POST	5	4	53.75	2.63
6	POST	7	6	59.83	3.55	3	5	59.00	6.00	4	6	53.00	8.74	8	4	51.50	11.96		15	POST	3	6	61.50	2.59
7	POST	8	6	52.67	10.23	4	6	55.33	6.38	3	5	62.80	1.64	7	5	61.40	3.29		15	POST	4	5	59.00	8.66
8	POST	12	6	55.33	9.61	6	6	56.83	8.77	5	4	60.50	6.35	11	7	52.71	10.98		15	POST	7	10	61.90	2.08
9	POST	9	6	53.67	10.17	2	6	61.50	2.88	1	5	61.40	3.13	10	5	54.20	11.73		15	POST	8	7	55.29	7.65
10	POST	4	6	53.67	9.61	8	6	59.00	6.39	7	4	61.25	2.50	3	6	48.00	7.04							
11	POST	11	6	61.33	1.97	12	6	54.17	12.20	6	6	59.67	4.18	5	6	58.33	3.93							
12	POST	2	6	60.17	4.02	9	5	60.20	1.79	10	6	49.83	12.73	1	5	58.60	6.77							
TREATMENT EFFECT	POST			55.88	3.52			57.57	3.07			56.65	5.22			54.45	4.99			POST			58.37	3.85

TABLE D-29

Ecology Unit Opinions (Attitude Toward Ecology Curriculum)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	POST	10	6	26.17	7.00	1	5	33.80	1.92	9	6	28.67	6.25	2	6	33.83	2.64		13	POST	1	3	32.33	4.23
2	POST	6	5	25.20	3.96	5	6	27.83	5.53	11	5	29.60	6.02	12	7	26.86	9.46		13	POST	2	3	33.00	1.00
3	POST	1	6	34.33	1.86	10	6	28.83	5.85	2	6	33.83	1.83	9	6	28.17	6.59		13	POST	9	5	33.00	4.06
4	POST	3	6	24.67	7.84	7	6	31.50	4.76	8	6	27.83	6.18	4	5	27.60	6.15		13	POST	10	7	29.86	5.73
5	POST	5	5	28.80	8.93	11	6	28.83	9.04	12	5	28.60	6.91	6		NO	DATA		14	POST	5	4	24.00	4.32
6	POST	7	6	32.83	2.71	3	5	31.60	4.28	4	6	26.50	4.28	8	4	27.50	8.27		15	POST	3	6	33.83	1.94
7	POST	8	6	28.67	6.19	4	6	29.33	5.28	3	5	30.80	6.61	7	5	32.80	2.49		15	POST	4	5	30.20	8.31
8	POST	12	6	30.50	5.92	6	6	31.33	5.50	5	4	29.00	5.48	11	7	30.00	5.26		15	POST	7	10	33.80	2.74
9	POST	9	6	30.67	5.57	2	6	35.67	0.52	1	5	34.20	1.30	10	5	32.40	4.98		15	POST	8	7	27.71	7.23
10	POST	4	6	28.17	5.56	8	6	34.50	3.67	7	4	32.25	4.50	3	6	24.33	6.80							
11	POST	11	6	35.00	1.10	12	6	30.33	3.98	6	6	32.83	4.26	5	6	29.50	3.57							
12	POST	2	6	34.67	0.82	9	5	32.80	5.07	10	6	27.33	8.24	1	5	32.80	2.39							
TREATMENT EFFECT	POST			29.97	3.66			31.36	2.47			30.12	2.61			29.62	3.04			POST			30.86	3.30

TABLE D-30

Ecology Discussion Attitude Scale (Attitude toward Thought Questions) Study I Descriptive Statistics

ECOLOGY TEACHER ID		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT			
		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	POST	10	5	25.20	6.38	1	4	33.50	3.70	9	6	28.83	8.06
2	POST	6	5	29.60	3.05	5	6	30.67	3.67	11	5	30.00	5.61
3	POST	1	6	33.33	2.80	10	6	30.00	4.47	2	6	34.50	5.17
4	POST	3	6	30.00	8.10	7	6	29.50	8.19	8	5	34.40	2.30
5	POST	5	6	32.17	5.78	11	6	30.17	8.75	12	4	33.25	5.25
6	POST	7	6	35.00	2.28	3	4	33.25	3.86	4	4	31.00	4.55
7	POST	8	5	32.40	8.65	4	5	30.80	6.50	3	6	28.67	9.63
8	POST	12	6	33.83	5.49	6	6	36.83	6.77	5	5	34.00	4.85
9	POST	9	6	29.33	7.74	2	6	38.83	3.13	1	6	37.00	4.98
10	POST	4	6	29.33	3.39	8	5	37.20	6.98	7	5	34.60	4.15
11	POST	11	6	35.17	4.75	12	5	35.20	4.60	6	6	36.00	5.66
12	POST	2	5	33.40	8.68	9	5	32.40	7.89	10	6	27.50	4.59
TREATMENT EFFECT	POST			31.56	2.93			33.19	3.18			32.23	3.10

TABLE D-31

Ecology Discussion Attitude Scale (Attitude toward Discussion)
Study I Descriptive Statistics

ECOLOGY TEACHER		PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	POST	10	5	49.60	12.22	1	4	61.00	10.03	9	6	52.00	7.80
2	POST	6	5	50.00	5.24	5	6	53.00	8.15	11	5	53.40	6.57
3	POST	1	6	50.83	13.12	10	5	54.80	8.90	2	6	60.67	9.76
4	POST	3	6	57.17	8.86	7	6	55.67	11.99	8	5	59.40	8.56
5	POST	5	6	56.83	10.05	11	6	58.00	12.82	12	4	61.00	8.29
6	POST	7	6	59.00	8.37	3	4	61.75	7.63	4		52.25	8.18
7	POST	8	5	58.20	11.84	4	5	55.00	8.94	3	6	53.67	14.95
8	POST	12	6	61.83	7.52	6	6	64.17	12.04	5	5	57.20	10.31
9	POST	9	6	53.50	14.99	2	6	70.17	3.49	1	6	66.83	6.18
10	POST	4	6	57.17	8.86	8	5	66.40	8.20	7	5	59.60	10.95
11	POST	11	6	63.83	9.28	12	5	64.40	6.19	6	6	61.17	8.28
12	POST	2	5	66.60	3.91	9	5	60.60	9.63	10	6	54.33	10.48
TREATMENT EFFECT	POST			67.68	5.86			60.41	5.28			57.62	4.57

TABLE D-32

Written Exercise Attitude Scale
(Attitude toward Thought Questions and Written Exercises)
Study I Descriptive Statistics -- Written Exercise Treatment

ECOLOGY TEACHER		ATTITUDE TOWARD THOUGHT QUESTIONS				ATTITUDE TOWARD DISCUSSIONS	
ID		CLASS	N	$\bar{X}$	SD	$\bar{X}$	SD
1	POST	1	3	33.33	8.14	42.67	5.03
2	POST	2	2	38.00	0.00	39.50	2.12
3	POST	9	5	34.00	6.44	39.00	5.66
4	POST	10	7	30.43	6.24	32.71	6.18
5	POST	5	4	20.00	7.07	21.50	7.14
6	POST	3	5	31.00	5.20	35.80	5.26
7	POST	4	4	34.25	8.42	39.75	6.40
8	POST	7	10	33.80	4.13	37.90	4.86
9	POST	9	7	30.29	3.77	33.57	7.39
TREATMENT EFFECT	POST			31.68	4.99	35.82	6.23

TABLE D-33

Ecology Art Project Scale (Attitude toward Art Projects)
Study I Descriptive Statistics

ECOLOGY TEACHER		ART ACTIVITY TREATMENT I			
ID		CLASS	N	$\bar{X}$	SD
1	POST	2	5	66.40	7.23
2	POST	12	7	59.00	13.00
3	POST	9	6	61.67	10.61
4	POST	4	3	64.33	8.33
5	POST	6		NO	DATA
6	POST	8	5	71.10	3.16
7	POST	7	5	62.40	9.71
8	POST	11	7	60.14	10.64
9	POST	10	5	59.20	6.14
10	POST	3	6	46.33	5.57
11	POST	5	6	63.33	10.56
12	POST	1	5	66.60	9.66
EFFECTIVE TREATMENT	POST			61.85	6.28

TABLE D-34

Number of Treatment Sessions Attended
Study I Descriptive Statistics

ECOLOGY TEACHER	PROBING AND REDIRECTION TREATMENT				NO PROBING AND REDIRECTION TREATMENT				FILLER ACTIVITY TREATMENT				ART ACTIVITY TREATMENT I					WRITTEN EXERCISE TEACHER		WRITTEN EXERCISE TREATMENT			
ID	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD		ID		CLASS	N	$\bar{X}$	SD
1	10	6	7.33	3.89	1	6	9.33	0.82	9	6	7.67	1.63	2	6	9.67	0.82		13		1	3	9.00	1.00
2	6	6	9.83	0.41	5	6	9.83	0.41	11	6	9.33	0.82	12	7	9.71	0.49		13		2	3	9.00	1.73
3	1	6	9.00	1.26	10	6	9.00	0.89	2	6	9.33	0.82	9	6	9.00	2.00		13		9	5	9.60	0.89
4	3	6	8.83	1.94	7	6	9.67	0.82	8	6	8.00	2.45	4	5	9.60	0.55		13		10	8	9.38	0.74
5	5	6	9.83	0.41	11	6	9.83	0.41	12	6	7.50	3.83	6		NO	DATA		14		5	5	9.40	0.89
6	7	6	8.17	2.23	3	6	9.83	0.41	4	6	9.00	1.55	8	5	9.00	0.71		15		3	6	9.67	0.52
7	8	6	3.83	1.60	4	6	8.50	1.64	3	6	9.33	1.21	7	6	9.17	1.33		15		4	5	9.00	1.00
8	12	6	9.00	1.10	6	6	9.17	1.17	5	5	8.80	1.64	11	7	9.86	0.38		15		7	10	9.20	1.03
9	9	6	10.00	0.00	2	6	9.17	1.33	1	6	9.67	0.52	10	6	9.50	0.55		15		8	8	8.88	1.55
0	4	6	9.00	1.67	8	6	9.50	0.55	7	6	8.83	1.33	3	6	9.67	0.52							
1	11	6	9.50	0.84	12	6	9.50	0.84	6	6	9.17	1.33	5	6	9.67	0.82							
2	2	6	9.00	1.10	9	6	8.83	1.47	10	6	9.83	0.41	1	6	0.50	1.64							
EATMENT FECT			9.03	0.75			9.34	0.43			8.87	0.76			9.39	0.42						9.23	0.29

APPENDIX E

Study II Descriptive Statistics: Measures of Student Ability, Achievement, Attitudes, and Attendance

TABLE [illegible]

Comprehensive Test of Basic Skills (Vocabulary, Comprehension, and Total Reading Score)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	VOCAB.	28	6	32.50	5.68	21	5	30.20	2.59	22	5	36.60	5.94	27	10	28.40	6.22
	COMP.		6	26.17	10.26		5	34.00	4.18		5	39.00	2.00		10	30.80	9.20
	TOTAL		6	58.67	15.59		5	64.20	5.54		5	75.80	7.79		10	59.20	15.16
2	VOCAB.	32	5	28.60	5.46	25	5	31.40	5.13	31	5	34.40	1.82	26	13	31.46	7.24
	COMP.		5	29.80	8.70		5	30.40	9.21		5	37.20	4.55		13	34.38	6.86
	TOTAL		5	58.40	13.99		5	61.80	12.68		5	71.60	4.72		13	65.85	11.55
3	VOCAB.	24	6	32.17	9.91	29	4	32.25	4.99	30	6	32.00	6.00	23	13	35.46	3.66
	COMP.		6	33.67	10.50		4	35.75	4.35		6	39.17	20.15		13	38.31	4.33
	TOTAL		6	65.83	20.10		4	68.00	9.31		6	71.17	12.66		13	73.77	7.82
4	VOCAB.	22	6	35.50	4.76	27	6	30.33	5.01	21	6	28.17	8.23	28	8	31.00	10.00
	COMP.		6	37.33	3.98		6	33.17	9.11		6	27.33	9.02		8	32.00	10.36
	TOTAL		6	72.83	8.23		5	63.50	14.94		6	55.50	17.10		8	63.00	19.84
5	VOCAB.	23	4	31.75	5.44	30	6	33.17	6.46	24	6	32.00	4.86	29	14	29.64	9.18
	COMP.		4	32.25	4.79		6	35.33	5.32		6	36.83	4.66		14	33.43	7.01
	TOTAL		4	64.00	9.83		6	68.50	11.48		6	68.83	7.83		14	63.07	14.98
6	VOCAB	30	6	31.00	6.32	23	6	29.17	6.24	29	6	27.00	3.63	24	10	34.50	4.17
	COMP		6	34.50	5.47		6	32.17	10.48		6	30.17	7.44		10	37.20	5.07
	TOTAL		6	65.50	11.54		6	61.33	16.48		6	57.17	5.95		10	71.70	8.94
7	VOCAB	31	5	31.20	10.21	26	6	30.33	6.65	25	6	32.83	5.31	32	7	28.43	2.22
	COMP		5	34.00	9.30		6	34.33	9.22		6	36.33	6.44		7	32.57	5.56
	TOTAL		5	65.20	18.89		6	64.67	15.49		6	69.17	10.15		7	61.00	7.02
8	VOCAB	26	6	27.83	6.76	31	6	30.67	2.80	32	6	30.83	7.60	25	10	33.50	5.85
	COMP		6	25.67	10.71		6	36.33	4.55		6	33.17	6.46		10	35.50	5.10
	TOTAL		6	53.50	16.79		6	67.00	5.69		6	64.00	13.52		10	69.00	6.70
9	VOCAB	29	5	28.40	7.33	24	5	32.20	6.65	23	6	29.17	6.79	30	11	24.64	7.16
	COMP		5	31.00	10.22		5	35.20	5.12		6	32.67	9.02		11	26.27	9.61
	TOTAL		5	59.40	17.44		5	67.40	10.71		6	61.83	15.56		11	50.91	16.29
10	VOCAB	25	5	26.80	3.83	32	4	31.50	3.70	26	6	29.00	5.18	31	8	25.00	13.22
	COMP		5	26.80	12.34		4	33.00	4.76		6	33.00	4.47		9	46.22	25.62
	TOTAL		5	53.60	15.68		4	64.50	8.35		6	62.00	9.01		8	71.22	24.54
11	VOCAB	21	5	29.80	5.67	28	6	34.00	12.39	27	5	28.80	7.79	22	14	32.64	4.38
	COMP		5	31.00	5.10		6	39.33	17.74		5	30.00	13.55		14	36.28	3.38
	TOTAL		5	60.80	8.96		6	68.50	19.68		5	58.80	20.33		14	68.93	6.75
12	VOCAB	27	6	29.00	11.58	22	6	29.50	4.14	28	4	17.50	5.57	21	13	27.92	6.36
	COMP		6	33.50	11.73		6	30.17	3.87		4	15.50	6.66		13	28.46	7.40
	TOTAL		6	62.50	23.18		6	59.67	7.58		4	33.00	11.34		13	56.38	12.70
TREATMENT EFFECT	VOCAB			30.38	2.44			31.22	1.47			29.86	4.78			30.21	3.51
	COMP			31.30	3.64			34.10	2.57			32.53	6.54			34.28	5.15
	TOTAL			61.68	5.50			65.32	2.97			62.39	10.90			64.49	6.61

TABLE E-2

Ecology Information Test (Total Scale)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	10.67	2.16	21	5	12.00	4.95	22	6	13.67	4.32	27	11	11.27	3.35
	POST		6	16.67	2.16		5	14.40	2.41		6	19.67	6.47		11	14.36	5.28
	DELAY		6	16.83	3.49		4	13.75	4.79		5	18.60	6.84		11	13.73	4.52
2	PRE	32	6	10.67	2.66	25	5	9.40	2.88	31	6	12.17	4.07	26	15	10.20	3.76
	POST		6	17.33	4.13		5	13.20	4.15		6	17.83	5.04		15	14.93	5.02
	DELAY		6	16.00	6.90		4	12.25	5.56		6	17.50	5.24		15	12.53	5.18
3	PRE	24	6	9.67	4.03	29	6	8.50	3.56	30	6	10.33	4.27	23	13	13.00	3.06
	POST		6	15.67	6.38		5	14.00	5.29		6	20.00	6.90		11	17.09	5.13
	DELAY		4	17.50	6.40		6	11.83	5.78		6	18.83	7.19		14	16.29	5.76
4	PRE	22	6	15.00	5.06	27	5	11.80	2.49	21	6	9.17	2.86	28	9	11.00	3.32
	POST		6	22.00	3.35		6	15.83	5.56		6	16.67	4.93		9	13.00	5.41
	DELAY		6	22.00	3.52		6	16.83	6.01		6	13.33	5.47		8	13.13	5.17
5	PRE	23	6	12.83	2.14	30	6	11.67	3.93	24	6	11.17	3.60	29	13	10.62	3.18
	POST		6	18.00	2.53		6	18.00	5.83		6	19.33	3.88		13	15.08	5.25
	DELAY		6	18.50	3.21		6	17.83	5.49		6	16.83	4.62		14	14.00	4.95
6	PRE	30	6	12.50	5.47	23	5	12.20	2.28	29	6	10.83	0.98	24	13	11.54	2.47
	POST		5	20.80	3.77		5	13.40	5.18		5	15.60	2.61		14	14.57	4.01
	DELAY		6	18.00	6.36		6	11.67	4.68		6	14.50	3.39		13	14.23	4.88
7	PRE	31	6	10.00	3.74	26	6	10.17	4.58	25	6	12.67	2.42	32	9	11.67	3.32
	POST		5	18.80	5.97		6	17.50	5.58		6	18.33	3.72		9	15.44	6.78
	DELAY		5	16.60	6.88		6	17.17	5.12		6	16.83	4.54		8	15.13	6.96
8	PRE	26	6	10.83	2.14	31	6	11.17	2.32	32	6	12.33	2.42	25	13	11.62	2.84
	POST		6	18.00	7.24		5	16.80	4.71		6	20.00	1.79		12	17.25	5.01
	DELAY		6	16.83	6.08		5	17.80	2.95		6	18.50	2.43		10	17.10	3.87
9	PRE	29	6	9.83	2.32	24	6	9.50	2.74	23	5	12.60	5.22	30	11	7.82	3.68
	POST		6	15.17	4.22		6	15.17	5.49		5	15.40	5.98		13	12.69	4.71
	DELAY		5	14.80	6.38		6	10.67	5.72		6	13.00	5.18		12	10.83	5.15
10	PRE	25	6	10.00	2.97	32	6	11.50	2.35	26	6	11.00	3.35	31	9	9.89	2.26
	POST		5	18.60	3.91		6	16.50	3.02		6	15.67	6.12		11	14.91	5.45
	DELAY		4	17.25	6.02		6	15.00	2.76		6	15.17	6.85		9	14.22	4.92
11	PRE	21	6	10.50	2.74	28	5	11.80	2.68	27	6	10.67	3.72	22	14	11.64	3.77
	POST		6	17.83	5.15		6	16.67	5.12		6	14.17	5.08		15	15.80	5.37
	DELAY		6	18.00	4.10		6	17.00	5.37		6	16.17	5.56		14	14.00	7.30
12	PRE	27	6	11.67	3.08	22	6	11.00	2.76	28	6	9.33	2.88	21	15	9.73	3.37
	POST		6	17.00	6.81		6	15.50	3.27		6	11.33	4.37		15	12.80	4.28
	DELAY		6	17.67	5.99		5	13.00	3.67		4	8.50	1.73		13	11.69	4.29
TREATMENT EFFECT	PRE			11.18	1.58			10.89	1.21			11.32	1.38			10.83	1.32
	POST			17.99	1.94			15.58	1.58			17.00	2.69			14.82	1.50

Ecology Information Test (Intentional Scale II)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	3.33	1.03	21	5	3.60	2.30	22	6	3.50	1.38	27	11	3.55	1.13
	POST		6	6.83	0.75		5	5.40	0.89		6	6.83	1.17		11	5.27	1.19
	DELAY		6	7.17	0.75		4	5.50	1.00		5	6.40	1.82		11	5.00	1.67
2	PRE	32	6	4.00	1.26	25	5	3.00	1.41	31	6	4.00	0.63	26	15	3.47	1.41
	POST		6	6.00	1.10		5	5.40	2.19		6	6.83	1.17		15	5.60	1.96
	DELAY		6	6.17	2.14		4	5.25	0.96		6	6.17	1.72		15	4.87	2.00
3	PRE	24	6	2.67	1.63	29	6	3.17	1.17	30	6	4.00	1.41	23	13	3.85	0.55
	POST		6	5.67	2.16		5	6.00	2.45		6	6.83	1.47		11	5.91	1.04
	DELAY		4	6.50	1.73		6	5.33	1.50		6	6.52	1.87		14	5.21	1.58
4	PRE	22	6	4.50	1.38	27	5	3.60	0.89	21	6	2.50	1.22	28	9	4.11	1.37
	POST		6	7.00	1.10		6	6.00	1.55		6	6.50	1.98		9	4.67	1.73
	DELAY		6	7.33	1.21		6	5.83	2.14		6	5.33	3.20		8	4.75	2.05
5	PRE	23	6	4.00	0.63	30	6	3.50	1.64	24	6	3.83	0.98	29	13	3.38	0.96
	POST		6	5.50	0.55		6	6.50	1.64		6	6.83	0.41		13	5.38	1.71
	DELAY		6	6.17	1.33		6	5.67	1.97		6	6.17	0.98		14	5.00	1.92
6	PRE	30	6	4.17	1.47	23	5	3.40	1.14	29	6	4.33	1.21	24	13	4.08	1.19
	POST		5	7.40	0.55		5	4.80	1.92		5	6.60	0.89		14	4.93	1.64
	DELAY		6	5.67	2.42		6	4.17	2.32		6	6.17	1.17		13	4.62	1.56
7	PRE	31	6	3.00	1.67	26	6	3.33	1.37	25	6	3.17	0.75	32	9	4.33	1.41
	POST		5	6.20	2.17		6	6.83	1.60		6	6.50	1.05		9	5.67	2.12
	DELAY		5	5.80	2.05		6	6.50	1.87		6	6.50	1.52		8	5.63	2.26
8	PRE	26	6	3.00	0.89	31	6	3.17	0.98	32	6	3.50	1.64	25	13	3.69	1.44
	POST		6	6.00	2.97		5	6.20	0.84		6	6.67	1.21		12	5.92	1.78
	DELAY		6	6.33	2.25		5	6.00	0.71		6	6.83	1.47		10	5.50	1.35
9	PRE	29	6	3.50	0.84	24	6	3.50	1.38	23	5	3.40	1.82	30	11	3.00	1.61
	POST		6	6.67	1.03		6	6.33	1.63		5	5.20	2.77		13	4.92	1.61
	DELAY		5	5.20	2.39		6	4.17	2.48		6	4.00	2.10		12	3.75	1.71
10	PRE	25	6	3.50	0.84	32	6	5.00	0.63	26	6	3.67	1.75	31	9	2.22	1.20
	POST		5	6.00	0.71		6	5.83	0.98		6	6.33	1.37		11	4.73	2.33
	DELAY		4	5.50	1.91		6	5.33	1.37		6	5.67	2.50		9	4.67	2.18
11	PRE	21	6	3.17	0.75	28	5	4.00	1.41	27	6	3.33	1.37	22	14	3.64	1.39
	POST		6	6.33	1.63		6	5.83	2.14		6	5.67	1.75		15	5.33	1.68
	DELAY		6	6.00	1.41		6	5.50	2.51		6	6.17	1.47		14	4.14	2.77
12	PRE	27	6	4.17	1.17	22	6	3.83	1.72	28	6	3.67	1.75	21	15	3.13	1.30
	POST		6	5.67	1.86		6	6.17	1.17		6	4.67	1.37		15	4.73	1.58
	DELAY		6	5.50	2.26		5	5.20	3.27		4	3.50	1.73		13	4.23	1.92
TREATMENT EFFECT	PRE			3.58	.58			3.69	.53			3.57	.47			3.53	.57
	POST			6.27	.59			5.94	.55			6.28	.72			5.25	.46
	DELAY			6.11	.65			5.37	.57			5.78	1.03			4.78	.55

TABLE E-4

Ecology Information Test (25% Intentional Scale)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	2.33	1.51	21	5	3.40	1.67	22	6	3.33	1.21	27	11	3.55	1.44
	POST		6	3.83	0.98		5	3.40	1.14		6	4.17	2.40		11	3.64	1.96
	DELAY		6	4.17	1.72		4	2.75	2.22		5	4.20	2.05		11	3.64	1.57
2	PRE	32	6	2.50	1.38	25	5	3.00	0.71	31	6	2.67	2.16	26	15	2.40	1.45
	POST		6	4.50	1.38		5	2.40	1.82		6	3.67	1.75		15	3.07	1.67
	DELAY		6	3.67	2.34		4	2.75	3.10		6	3.50	1.87		15	2.53	1.81
3	PRE	24	6	3.00	1.10	29	6	2.50	1.05	30	6	2.33	1.37	23	13	3.15	1.21
	POST		6	4.00	2.10		5	3.40	1.67		6	4.50	2.43		11	4.00	1.67
	DELAY		4	4.75	2.50		6	2.83	1.83		6	4.83	1.83		14	3.79	1.53
4	PRE	22	6	4.17	1.47	27	5	2.20	0.84	21	6	2.33	1.37	28	9	2.56	1.24
	POST		6	5.67	0.82		6	3.50	1.38		6	3.67	1.21		9	3.89	1.45
	DELAY		6	5.50	1.22		6	3.83	1.47		6	3.00	0.63		8	3.50	1.20
5	PRE	23	6	2.67	1.03	30	6	2.83	1.17	24	6	2.67	1.03	29	13	2.77	1.09
	POST		6	5.00	1.79		6	4.00	2.37		6	5.17	1.33		13	3.31	1.65
	DELAY		6	4.67	1.21		6	4.83	1.72		6	4.50	0.84		14	3.50	1.22
6	PRE	30	6	3.83	1.72	23	5	2.20	0.84	29	6	2.67	0.52	24	13	2.69	1.03
	POST		5	5.40	1.34		5	3.60	1.14		5	3.20	1.30		14	4.14	1.23
	DELAY		6	5.00	2.10		6	2.67	1.03		6	3.50	1.87		13	4.23	1.59
7	PRE	31	6	2.50	1.22	26	6	2.33	1.63	25	6	3.17	0.41	32	9	2.89	1.17
	POST		5	4.60	0.89		6	3.83	1.94		6	3.83	1.17		9	3.78	1.99
	DELAY		5	4.00	1.87		6	4.33	1.37		6	3.83	0.75		8	3.50	1.93
8	PRE	26	6	2.83	1.33	31	6	3.17	0.98	32	6	3.83	1.17	25	13	2.85	0.90
	'POST		6	4.33	1.75		5	4.20	1.92		6	5.50	0.84		12	4.25	2.05
	DELAY		6	4.17	1.72		5	4.80	0.84		6	5.00	0.89		10	4.40	2.07
9	PRE	29	6	1.50	0.84	24	6	2.00	1.79	23	5	2.60	1.52	30	11	2.18	1.66
	POST		6	3.50	1.22		6	3.67	2.06		5	3.80	1.10		13	2.85	1.41
	DELAY		5	3.80	1.79		6	3.17	2.32		6	3.50	1.05		12	2.67	1.56
10	PRE	25	6	2.50	1.87	32	6	2.83	0.75	26	6	3.33	1.03	31	9	2.56	1.13
	POST		5	4.80	1.79		6	4.50	1.64		6	4.17	2.48		11	4.09	1.38
	DELAY		4	5.00	1.82		6	4.17	1.60		6	4.00	2.19		9	4.33	1.32
11	PRE	21	6	2.50	1.38	28	5	2.80	0.84	27	6	2.83	1.47	22	14	3.00	1.47
	POST		6	4.83	0.98		6	3.83	1.33		6	3.33	1.86		15	4.07	1.71
	DELAY		6	4.17	1.47		6	3.83	1.60		6	3.33	1.75		14	3.93	2.13
12	PRE	27	6	2.67	1.37	22	6	2.00	0.00	28	6	2.00	1.10	21	15	2.47	1.41
	POST		6	4.83	2.14		6	3.33	1.97		6	2.33	0.82		15	2.93	1.67
	DELAY		6	4.67	1.86		5	3.60	1.67		4	1.25	0.96		13	3.08	1.50
TREATMENT	PRE			2.75	0.69			2.60	0.46			2.81	0.52			2.75	0.37
	POST			4.61	0.63			3.64	0.52			3.94	0.85			3.66	0.50
EFFECT	DELAY			4.46	0.55			[illegible]	[illegible]			[illegible]	[illegible]			[illegible]	0.61

Ecology Information Test (Incidental Scale II)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	4.50	0.84	21	5	4.20	1.92	22	6	5.67	2.16	27	11	3.82	1.72
	POST		6	4.67	1.21		5	4.60	1.14		6	7.17	2.32		11	4.45	2.54
	DELAY		6	4.50	1.87		4	4.50	1.73		5	6.60	2.88		11	4.00	2.28
2	PRE	32	6	3.83	1.72	25	5	3.00	1.58	31	6	4.33	1.63	26	15	3.67	1.63
	POST		6	5.67	1.86		5	4.60	1.82		6	6.17	2.32		15	5.27	2.31
	DELAY		6	5.17	2.71		4	3.50	2.52		6	6.50	2.17		15	4.33	1.91
3	PRE	24	6	3.83	2.64	29	6	2.83	1.72	30	6	3.33	2.34	23	13	5.46	1.61
	POST		6	4.83	2.64		5	4.20	1.92		6	7.17	2.79		11	6.00	2.86
	DELAY		4	5.50	2.08		6	3.33	2.25		6	6.50	3.39		14	6.36	2.84
4	PRE	22	6	5.67	2.16	27	5	4.80	0.84	21	6	3.33	1.37	28	9	3.89	1.54
	POST		6	7.67	1.97		6	5.00	2.45		6	5.67	2.42		9	3.89	2.42
	DELAY		6	7.50	2.34		6	5.83	2.14		6	4.50	2.59		8	4.13	2.53
5	PRE	23	6	5.33	1.50	30	6	4.33	2.25	24	6	4.00	2.28	29	13	3.85	2.19
	POST		6	6.50	1.22		6	6.33	1.97		6	5.83	1.94		13	5.62	2.53
	DELAY		6	7.00	1.55		6	6.17	2.64		6	5.00	2.83		14	4.64	2.50
6	PRE	30	6	3.83	2.32	23	5	6.40	2.07	29	6	3.17	0.98	24	13	4.46	1.71
	POST		5	6.20	2.05		5	4.00	2.00		5	5.00	2.00		14	4.93	2.06
	DELAY		6	5.83	2.14		6	3.83	1.47		6	3.83	2.71		13	4.69	2.36
7	PRE	31	6	3.50	1.38	26	6	4.33	2.25	25	6	5.50	2.26	32	9	3.67	1.87
	POST		5	6.40	2.88		6	5.50	2.43		6	6.50	1.97		9	5.00	2.96
	DELAY		5	5.80	2.39		6	5.00	2.53		6	5.33	2.88		8	5.00	3.02
8	PRE	26	6	4.17	1.17	31	6	4.17	1.67	32	6	4.67	1.21	25	13	4.38	1.71
	POST		6	6.50	2.17		5	5.20	1.79		6	7.00	1.26		12	6.00	1.81
	DELAY		6	5.17	2.67		5	5.60	1.67		6	6.00	1.41		10	6.10	1.37
9	PRE	29	6	4.17	2.23	24	6	3.50	1.97	23	5	6.00	1.87	30	11	2.18	1.33
	POST		6	4.33	2.50		6	4.33	2.16		5	5.20	2.86		13	4.23	1.88
	DELAY		5	5.00	2.74		6	2.83	1.72		6	4.83	2.48		12	3.75	1.86
10	PRE	25	6	3.33	1.63	32	6	3.17	1.33	26	6	3.50	1.22	31	9	4.33	1.58
	POST		5	6.60	1.34		6	5.17	1.60		6	4.50	2.26		11	5.45	1.69
	DELAY		4	5.50	2.89		6	4.67	1.50		6	4.67	2.34		9	4.67	1.73
11	PRE	21	6	4.00	1.10	28	5	4.40	0.55	27	6	3.67	2.50	22	14	4.14	1.92
	POST		6	5.33	2.06		6	6.50	1.87		6	4.67	2.88		15	5.53	2.70
	DELAY		6	6.17	1.47		6	7.00	1.79		6	5.67	2.66		14	5.14	2.66
12	PRE	27	6	4.33	1.37	22	6	4.83	1.47	28	6	3.17	1.33	21	15	3.73	1.22
	POST		6	5.67	3.14		6	5.50	1.64		6	4.00	2.37		15	4.27	2.02
	DELAY		6	6.50	2.07		5	3.80	1.30		4	3.50	0.58		13	4.00	1.63
TREATMENT EFFECT	PRE			4.20	0.69			4.16	0.98			4.19	1.04			3.96	0.76
	POST			5.86	0.96			5.08	0.79			5.74	1.08			5.05	0.71
	DELAY			5.80	0.87			4.67	1.28			5.24	1.04			4.73	0.82

TABLE E-6

Oral Test (Content Scale)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	7.50	3.13	21	6	8.33	4.26	22	6	9.92	2.62	27	12	8.04	2.34
	POST		6	9.17	1.63		5	10.10	3.17		6	8.67	2.42		11	8.18	4.11
2	PRE	32	4	4.12	2.78	25	5	5.10	2.63	31	4	2.25	3.86	26	13	3.85	3.62
	POST		5	8.60	2.41		6	8.08	2.67		6	7.67	3.39		13	7.73	1.88
3	PRE	24	6	6.42	2.67	29	5	5.20	2.97	30	6	5.50	2.26	23	14	8.75	2.29
	POST		5	8.70	3.17		5	9.80	1.20		6	9.33	1.99		13	8.58	2.51
4	PRE	22	6	7.58	1.83	27	6	7.42	2.67	21	6	7.08	2.20	28	9	7.39	2.79
	POST		5	8.90	1.64		6	9.17	2.34		6	9.17	2.91		7	8.57	2.74
5	PRE	23	6	6.83	2.94	30	6	7.83	2.96	24	6	4.67	1.78	29	11	5.00	2.91
	POST		6	8.50	1.79		6	10.17	4.37		6	7.83	2.09		13	6.92	2.87
6	PRE	30	6	5.50	2.57	23	6	7.33	4.69	29	6	5.83	2.14	24	12	6.42	2.28
	POST		6	6.00	3.35		5	10.40	3.49		5	8.70	2.93		14	7.61	2.03
7	PRE	31	4	5.38	4.37	26	5	5.40	2.88	25	5	5.00	2.55	32	7	5.86	3.66
	POST		6	10.42	1.74		6	8.92	2.33		6	9.17	1.21		9	7.78	1.46
8	PRE	26	5	0.70	0.67	31	5	7.00	2.47	32	5	4.90	2.27	25	8	4.12	3.26
	POST		6	8.50	3.03		5	8.40	1.95		5	10.30	1.04		11	7.18	2.67
9	PRE	29	6	4.67	2.96	24	6	5.25	3.31	23	4	7.38	5.20	30	12	5.17	2.61
	POST		6	7.75	3.71		6	7.25	4.30		6	8.00	6.89		12	5.17	2.23
10	PRE	25	5	5.40	5.28	32	5	5.80	2.66	26	6	2.58	2.13	31	10	4.10	3.04
	POST		6	10.92	4.38		6	9.75	2.02		6	7.92	2.90		9	6.83	2.22
11	PRE	21	4	8.62	3.61	28	6	7.17	2.68	27	6	7.60	3.16	22	14	7.75	1.91
	POST		5	8.90	2.01		6	7.75	2.68		6	5.33	2.99		15	7.07	2.18
12	PRE	27	6	7.50	2.59	22	6	8.33	13.29	28	6	7.17	2.16	21	14	6.57	3.97
	POST		6	9.08	1.86		6	12.50	14.05		6	7.67	1.44		14	6.57	2.97
TREATMENT EFFECT	PRE			5.85	2.11			6.56	1.14			5.82	2.18			6.08	1.67
	POST			8.78	1.22			9.02	1.04			8.31	1.24			7.34	.95

TABLE E-7

Oral Test (Logical Extension Scale)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	3.17	2.07	21	6	3.00	2.02	22	6	2.17	1.25	27	12	2.63	1.54
	POST		6	4.33	2.62		5	4.10	2.46		5	3.20	1.52		11	3.27	2.88
2	PRE	32	2	2.75	0.35	25	4	1.25	0.50	31	2	1.75	2.47	26	8	1.81	1.69
	POST		5	2.90	1.67		6	4.00	2.63		5	1.50	1.73		13	3.12	2.26
3	PRE	24	6	2.42	1.53	29	4	1.25	0.87	30	6	1.33	1.47	23	14	3.61	1.68
	POST		5	3.70	1.44		5	4.60	2.10		6	3.33	1.33		13	2.96	2.07
4	PRE	22	6	2.17	0.75	27	6	1.92	2.56	21	6	2.00	1.52	28	9	3.11	2.75
	POST		5	2.90	0.42		6	2.67	1.40		6	3.00	1.58		6	5.75	3.57
5	PRE	23	6	2.08	1.56	30	6	4.08	3.54	24	5	1.70	1.30	29	9	1.89	2.37
	POST		6	3.75	2.49		6	4.50	2.76		6	2.58	0.97		12	2.42	2.68
6	PRE	30	6	1.83	1.94	23	5	2.40	2.22	29	6	1.67	1.21	24	11	1.50	1.26
	POST		5	2.60	3.43		5	3.60	3.56		5	4.20	2.05		14	2.11	1.51
7	PRE	31	3	2.50	1.32	26	4	2.13	1.25	25	3	2.17	1.76	32	5	2.90	1.29
	POST		6	4.42	1.77		6	6.25	4.99		6	3.08	2.67		9	3.56	1.72
8	PRE	26		No	Data	31	4	2.25	1.44	32	3	3.50	1.00	25	6	1.83	1.25
	POST		6	4.50	3.85		5	3.60	2.58		5	3.70	3.21		10	2.90	2.18
9	PRE	29	4	1.50	1.73	24	6	2.17	2.88	23	3	7.33	4.04	30	11	1.82	1.76
	POST		5	2.90	1.29		6	2.92	2.89		5	5.50	7.84		12	1.04	1.16
10	PRE	25	3	1.00	1.00	32	3	3.50	0.50	26	4	0.88	0.85	31	7	1.14	1.49
	POST		6	5.25	1.97		6	3.58	2.18		6	3.75	1.44		8	2.25	1.98
11	PRE	21	4	2.00	1.22	28	6	2.92	2.08	27	6	2.17	1.60	22	14	3.00	1.64
	POST		5	4.90	1.56		5	4.00	1.90		5	2.60	2.22		15	3.37	1.80
12	PRE	27	6	2.42	2.71	22	6	2.25	0.88	28	6	1.50	1.41	21	14	2.29	2.30
	POST		6	3.67	2.11		6	3.33	2.16		6	1.58	1.24		13	2.96	3.22
TREATMENT EFFECT	PRE			2.12	0.56			2.43	0.83			2.35	1.69			2.29	0.74
	POST			3.81	0.87			3.93	0.93			3.17	1.09			2.98	1.11

TABLE E-8

Essay Test (Content Scale)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE POST	28	6 6	9.92 11.08	3.29 2.65	21	5 5	10.20 11.80	3.85 1.64	22	6 6	12.33 14.17	3.89 3.89	27	12 12	10.37 11.37	3.14 3.78
2	PRE POST	32	6 6	8.58 11.83	3.41 4.46	25	6 6	10.58 12.17	3.15 4.43	31	6 6	11.33 11.25	4.20 4.12	26	15 14	9.70 7.32	4.15 3.58
3	PRE POST	24	6 6	11.67 15.67	6.01 7.46	29	6 5	8.25 8.60	3.27 4.02	30	6 6	11.92 11.67	3.62 3.79	23	13 13	14.54 12.81	5.21 4.57
4	PRE POST	22	6 6	11.25 12.50	2.32 2.57	27	6 6	10.08 11.42	4.62 3.65	21	5 6	9.20 10.58	1.89 2.24	28	9 8	8.83 11.31	5.29 4.86
5	PRE POST	23	6 6	12.75 13.33	3.93 5.17	30	6 6	12.67 12.50	3.66 2.68	24	6 6	11.00 14.25	1.95 3.72	29	14 14	9.75 9.61	2.81 3.10
6	PRE POST	30	6 5	12.08 12.20	2.27 1.56	23	6 5	14.42 15.10	5.94 3.71	29	6 5	8.58 9.00	2.50 4.21	24	14 13	9.39 13.08	2.61 4.28
7	PRE POST	31	6 6	8.42 11.83	3.72 4.82	26	6 6	9.50 10.17	2.68 3.70	25	6 6	11.83 13.25	1.63 2.30	32	9 7	9.61 10.00	1.93 3.01
8	PRE POST	26	6 6	10.33 8.17	6.24 5.11	31	6 6	12.58 13.92	3.92 5.42	32	6 6	8.83 12.00	2.25 3.07	25	12 13	12.83 11.27	5.34 4.69
9	PRE POST	29	6 6	9.92 9.17	2.56 1.57	24	6 6	9.42 14.00	4.77 6.24	23	6 6	10.75 11.50	5.02 10.75	30	13 13	9.35 8.35	3.70 3.52
10	PRE POST	25	6 6	8.92 13.00	5.51 3.81	32	5 6	10.60 13.50	1.47 2.80	26	6 6	8.17 11.75	2.56 2.27	31	9 11	9.83 10.32	5.00 4.30
11	PRE POST	21	6 5	10.75 10.50	3.57 3.59	28	6 6	10.25 12.33	3.83 2.27	27	6 6	10.00 10.92	2.24 3.65	22	14 15	10.57 11.07	2.27 2.32
12	PRE POST	27	6 6	10.42 9.67	5.45 4.74	22	6 6	10.50 15.08	3.83 3.95	28	6 5	7.00 9.40	3.72 4.22	21	15 15	9.30 18.13	4.68 3.60
TREATMENT EFFECT	PRE POST			10.41 11.58	1.37 2.04			10.75 12.54	1.68 1.93			10.08 11.64	1.71 1.64			10.34 10.35	1.67 1.78

TABLE E-9

Essay Test (Logical Extension Scale)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	1.17	0.75	21	5	1.10	0.65	22	6	1.67	1.63	27	12	2.67	2.73
	POST		6	1.33	1.44		5	1.50	0.50		6	2.75	2.60		12	3.08	1.99
2	PRE	32	6	2.08	1.83	25	6	2.67	2.56	31	6	1.67	0.68	26	15	1.97	2.11
	POST		6	1.83	1.21		6	2.00	1.18		6	1.92	1.56		14	0.82	1.12
3	PRE	24	6	2.17	1.81	29	6	0.83	1.03	30	6	2.25	2.07	23	13	4.65	3.07
	POST		6	4.25	2.88		5	1.40	1.29		6	1.58	1.80		13	3.00	2.28
4	PRE	22	6	1.42	0.58	27	6	2.33	1.66	21	5	1.20	1.15	28	9	1.06	1.38
	POST		6	1.00	0.95		6	1.92	1.32		6	1.50	1.48		9	1.83	1.71
5	PRE	23	6	2.42	2.33	30	6	2.33	2.23	24	6	0.92	1.32	29	14	1.50	1.81
	POST		6	2.67	3.14		6	1.25	1.17		6	2.42	2.35		14	.93	.96
6	PRE	30	6	3.00	1.64	23	6	3.92	2.89	29	6	1.75	1.37	24	14	1.46	1.84
	POST		5	1.60	0.82		5	2.30	0.91		5	1.60	0.65		13	2.04	2.21
7	PRE	31	6	1.58	1.36	26	6	2.00	1.45	25	6	2.58	1.96	32	9	1.67	1.03
	POST		6	2.17	2.06		6	1.67	1.50		6	2.58	2.04		7	1.28	0.76
8	PRE	26	6	1.33	0.82	31	6	4.17	3.16	32	6	1.25	0.69	25	12	2.79	2.85
	POST		6	1.17	1.12		6	3.50	3.22		6	1.50	1.05		13	1.35	1.59
9	PRE	29	6	2.75	3.08	24	6	1.58	2.44	23	6	4.83	5.43	30	13	1.23	1.51
	POST		6	0.83	1.21		6	3.50	3.94		6	3.33	4.00		13	0.88	1.14
10	PRE	25	6	1.58	1.93	32	5	1.40	.96	26	6	1.00	1.26	31	9	1.11	1.08
	POST		6	3.50	3.74		6	1.83	1.75		6	1.67	1.66		11	2.18	1.79
11	PRE	21	6	3.08	3.88	28	6	1.83	2.29	27	6	1.33	1.72	22	14	1.43	1.14
	POST		5	2.70	0.57		6	4.00	2.97		6	2.42	3.46		15	1.27	1.44
12	PRE	27	6	2.67	2.64	22	6	1.58	2.01	28	6	1.17	1.25	21	15	2.03	2.00
	POST		6	2.17	4.36		6	2.75	2.02		5	1.10	1.02		15	1.33	1.40
TREATMENT EFFECT	PRE			2.10	0.68			2.14	1.03			1.30	1.08			1.96	1.02
	POST			2.10	1.04			2.30	0.92			2.03	0.66			1.66	0.78

TABLE E-10

Transfer Test (Content Scale)
Study II Descriptive Statistics

ECOLOGY TEACHER	25% HIGHER COGNITIVE QUESTIONS TREATMENT II			50% HIGHER COGNITIVE QUESTIONS TREATMENT II			75% HIGHER COGNITIVE QUESTIONS TREATMENT II			ART ACTIVITY TREATMENT II		
ID	CLASS N	$\overline{X}$	SD	CLASS N	$\overline{X}$	SD	CLASS N	$\overline{X}$	SD	CLASS N	$\overline{X}$	SD
1 DELAY	28 6	8.08	2.85	21 4	8.00	4.45	22 5	8.90	2.01	27 12	8.37	3.41
2 DELAY	32 6	8.25	5.45	25 5	10.40	2.10	31 6	8.83	2.29	26 15	6.77	3.19
3 DELAY	24 4	9.62	1.89	29 6	7.08	3.46	30 6	8.67	2.38	23 14	11.46	2.89
4 DELAY	22 6	9.17	3.42	27 6	8.67	3.20	21 6	6.92	3.54	28 8	7.69	4.63
5 DELAY	23 6	14.17	6.86	30 6	10.92	4.22	24 6	8.17	1.57	29 14	8.00	4.15
6 DELAY	30 6	8.67	1.83	23 6	9.42	3.15	29 6	7.92	2.44	24 13	8.54	2.27
7 DELAY	31 5	7.60	2.77	26 6	8.00	3.08	25 6	11.58	3.29	32 8	8.44	3.75
8 DELAY	26 6	8.08	3.22	31 5	10.10	4.34	32 6	7.25	4.78	25 12	11.04	5.63
9 DELAY	29 6	7.75	3.39	24 6	10.58	4.59	23 6	8.58	8.10	30 13	6.15	3.40
10 DELAY	25 5	11.50	5.88	32 6	8.92	3.25	26 6	8.83	2.56	31 10	9.05	4.73
11 DELAY	21 5	6.60	3.36	28 6	8.00	1.82	27 6	9.17	3.91	22 14	8.68	1.25
12 DELAY	27 6	6.75	4.80	22 6	8.83	4.01	28 5	7.20	3.82	21 13	6.42	3.76
TREATMENT DELAY EFFECT		8.85	2.13		9.07	1.22		8.50	1.23		8.38	1.63

TABLE E-1

Transfer Test (Logical Extension Scale)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	DELAY	28	6	0.67	0.60	21	4	2.12	2.53	22	5	1.40	1.52	27	12	1.33	2.07
2	DELAY	32	6	2.08	1.46	25	5	1.80	1.35	31	6	1.17	1.29	26	15	1.03	1.32
3	DELAY	24	4	1.00	0.91	29	6	1.00	1.38	30	6	2.17	1.81	23	14	2.50	1.80
4	DELAY	22	6	1.42	1.50	27	6	0.75	0.69	21	6	2.00	1.70	28	8	1.19	1.53
5	DELAY	23	6	4.33	3.52	30	6	1.67	1.63	24	6	1.58	1.43	29	14	1.18	1.23
6	DELAY	30	6	1.33	0.98	23	6	1.17	8.40	29	6	1.50	1.67	24	13	1.58	1.60
7	DELAY	31	5	1.10	1.14	26	6	1.92	1.28	25	6	1.75	1.94	32	8	1.81	0.65
8	DELAY	26	6	0.83	1.37	31	5	0.70	0.57	32	6	1.50	1.48	25	12	2.12	2.12
9	DELAY	29	6	0.75	0.61	24	6	2.92	2.85	23	6	3.00	4.23	30	13	0.62	0.94
10	DELAY	25	5	3.10	4.80	32	6	1.67	1.72	26	6	2.50	3.66	31	10	2.05	2.84
11	DELAY	21	5	2.40	2.07	28	6	1.58	1.50	27	6	2.17	2.48	22	14	1.54	1.36
12	DELAY	27	6	1.00	0.95	22	6	2.25	1.70	28	5	1.50	1.12	21	14	6.57	2.97
TREATMENT EFFECT	DELAY			1.67	1.12			1.63	0.65			1.85	0.53			1.96	1.54

TABLE E-12

Question-Generating Test, Paper-and-Pencil Measure (Number of Nonpertinent Questions)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	0.42	0.66	21	5	1.10	1.19	22	6	0.08	0.20	27	11	1.09	1.58
	POST		6	0.92	0.92		5	0.30	0.67		6	0.25	0.42		11	0.32	0.78
2	PRE	32	6	0.08	0.20	25	5	1.10	1.95	31	6	0.50	0.45	26	15	0.50	0.91
	POST		6	0.08	0.20		5	0.70	1.10		6	0.08	0.20		15	0.23	0.42
3	PRE	24	6	0.42	0.66	29	6	0.42	0.49	30	6	0.50	0.55	23	13	0.12	0.30
	POST		6	0.33	0.52		5	0.20	0.27		5	0.90	2.01		12	0.62	0.74
4	PRE	22	6	0.00	0.00	27	6	0.33	0.60	21	6	1.33	2.56	28	9	0.61	0.82
	POST		6	0.08	0.20		6	0.08	0.20		6	1.58	3.41		9	0.33	0.56
5	PRE	23	6	0.17	0.26	30	6	0.08	0.20	24	6	0.42	1.02	29	14	0.32	0.50
	POST		6	1.17	2.21		6	0.00	0.00		6	0.75	0.69		14	0.11	0.40
6	PRE	30	6	0.42	0.58	23	6	0.58	0.67	29	6	0.83	1.81	24	13	0.54	0.66
	POST		4	0.25	0.50		5	1.80	1.86		5	0.50	0.87		14	1.00	1.11
7	PRE	31	6	0.58	1.02	26	6	0.17	0.41	25	6	0.83	1.37	32	9	0.56	1.31
	POST		4	0.12	0.25		6	0.08	0.20		6	0.92	2.01		8	0.00	0.00
8	PRE	26	6	1.08	1.74	31	5	1.80	2.71	32	6	0.08	0.20	25	13	0.31	0.52
	POST		6	0.25	0.27		5	0.00	0.00		6	0.00	0.00		12	0.17	0.33
9	PRE	29	6	0.25	0.42	24	6	0.17	0.41	23	6	0.33	0.60	30	13	0.46	0.78
	POST		5	0.40	0.55		4	0.75	0.96		6	0.42	0.80		13	0.12	0.30
10	PRE	25	6	0.33	0.41	32	6	0.08	0.20	26	6	0.00	0.00	31	8	0.69	1.58
	POST		6	0.17	0.26		6	0.92	1.56		5	0.50	0.50		11	0.27	0.34
11	PRE	21	6	0.25	0.27	28	5	0.10	0.22	27	6	2.25	5.27	22	13	0.15	0.43
	POST		6	0.17	0.41		6	0.17	0.26		6	1.00	1.58		15	0.43	0.78
12	PRE	27	6	1.08	1.20	22	6	0.08	0.20	28	6	0.92	0.97	21	15	0.40	0.83
	POST		6	0.50	1.00		5	0.10	0.22		6	0.42	0.38		15	0.53	0.94
TREATMENT EFFECT	PRE			0.42	0.35			0.50	0.55			0.67	0.63			0.48	0.26
	POST			0.37	0.34			0.42	0.54			0.61	0.44			0.34	0.28

TABLE E-13

Question-Generating Test, Paper-and-Pencil Measure (Number of Pertinent Questions)
Study II Descriptive Statistics

ECOLOGY TEACHER ID		25% HIGHER COGNITIVE QUESTIONS TREATMENT II CLASS	N	$\bar{X}$	SD	50% HIGHER COGNITIVE QUESTIONS TREATMENT II CLASS	N	$\bar{X}$	SD	75% HIGHER COGNITIVE QUESTIONS TREATMENT II CLASS	N	$\bar{X}$	SD	ART ACTIVITY TREATMENT II CLASS	N	$\bar{X}$	SD
1	PRE	28	6	13.25	5.91	21	5	12.50	10.83	22	6	16.92	5.75	27	11	14.09	5.36
	POST		6	12.58	10.28		5	11.20	8.33		6	14.92	7.04		11	15.82	5.72
2	PRE	32	6	10.08	3.75	25	5	14.40	3.56	31	6	16.25	3.71	26	15	10.17	5.63
	POST		6	9.67	5.40		5	13.90	2.97		6	11.75	0.76		15	6.90	4.20
3	PRE	24	6	11.75	7.10	29	6	6.83	2.98	30	6	11.00	4.20	23	13	18.08	5.60
	POST		6	19.33	13.01		5	8.00	1.27		5	14.30	8.97		12	17.38	6.06
4	PRE	22	6	14.83	4.06	27	6	12.17	5.28	21	6	13.25	3.09	28	9	18.33	7.11
	POST		6	12.50	5.75		6	17.67	8.59		6	14.83	8.26		9	13.11	10.12
5	PRE	23	6	11.58	6.36	30	6	10.83	3.64	24	6	11.58	6.22	29	14	8.64	4.35
	POST		6	14.58	10.11		6	9.75	4.17		6	15.50	7.97		14	8.04	4.46
6	PRE	30	6	11.92	5.50	23	6	14.58	7.64	29	6	7.83	3.42	24	13	13.81	5.82
	POST		4	13.00	3.16		5	16.10	10.71		5	7.90	3.29		14	19.04	9.22
7	PRE	31	6	12.25	5.93	26	6	11.00	8.46	25	6	11.75	3.33	32	9	10.72	5.73
	POST		4	9.50	5.21		6	8.75	3.49		6	12.17	5.43		8	8.69	3.24
8	PRE	26	6	7.83	2.99	31	5	19.70	7.06	32	6	9.83	3.59	25	13	12.58	6.66
	POST		6	6.42	3.83		5	12.10	3.13		6	11.17	4.07		12	10.71	4.30
9	PRE	29	6	11.42	3.44	24	6	11.08	7.43	23	6	13.08	7.51	30	13	10.88	5.90
	POST		5	9.60	2.70		4	23.62	11.43		6	13.33	8.62		13	7.88	3.65
10	PRE	25	6	11.00	3.02	32	6	13.92	5.00	26	6	7.17	2.71	31	8	14.38	5.69
	POST		6	11.17	6.45		6	16.08	6.78		5	5.50	2.50		11	10.95	3.92
11	PRE	21	6	14.83	8.21	28	5	11.70	6.13	27	6	9.58	5.43	22	13	16.27	6.22
	POST		6	12.08	5.57		6	14.00	7.13		6	9.92	6.20		15	14.77	5.95
12	PRE	27	6	12.75	5.02	22	6	15.92	6.33	28	6	7.25	4.55	21	15	9.70	3.66
	POST		6	16.17	6.99		5	16.10	6.97		6	9.67	4.47		15	9.60	5.48
TREATMENT EFFECT	PRE			11.96	1.93			12.88	3.18			11.29	3.22			13.13	3.25
	POST			12.21	3.41			13.94	4.39			11.74	3.08			11.90	4.04

TABLE E-14

Question-Generating Test, Paper-and-Pencil Measure (Number of Specific Questions)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	1.67	1.33	21	5	2.00	0.50	22	6	4.17	2.99	27	11	5.23	3.58
	POST		6	2.17	1.99		5	1.80	1.89		6	4.58	1.53		11	5.73	4.87
2	PRE	32	6	2.42	2.01	25	5	4.90	2.28	31	6	3.25	3.72	26	15	3.47	4.43
	POST		6	2.25	1.97		5	5.80	3.42		6	5.17	4.06		15	1.93	2.33
3	PRE	24	6	2.00	2.28	29	6	0.92	2.24	30	6	1.92	2.46	23	13	2.58	2.39
	POST		6	5.50	4.64		5	2.10	2.58		5	1.00	1.22		12	3.08	2.55
4	PRE	22	6	2.25	2.32	27	6	3.75	4.14	21	6	4.17	3.68	28	9	4.06	2.73
	POST		6	3.42	3.12		6	5.92	3.85		6	3.50	3.27		9	3.89	5.51
5	PRE	23	6	2.25	2.34	30	6	3.00	3.30	24	6	3.75	3.25	29	14	1.39	1.81
	POST		6	4.50	5.27		6	3.08	2.62		6	5.08	6.87		14	1.43	2.02
6	PRE	30	6	3.17	2.98	23	6	3.75	2.12	29	6	0.92	0.67	24	13	2.35	3.31
	POST		4	2.88	4.01		5	5.80	5.73		5	1.70	1.56		14	3.32	2.58
7	PRE	31	6	2.58	2.44	26	6	4.08	5.47	25	6	4.00	3.76	32	9	1.78	2.53
	POST		4	4.75	3.48		6	3.08	2.20		6	2.00	2.26		8	1.25	1.20
8	PRE	26	6	2.33	1.54	31	5	4.30	3.60	32	6	1.25	1.22	25	13	4.85	4.01
	POST		6	0.58	0.66		5	4.80	4.10		6	4.17	3.70		12	3.08	2.82
9	PRE	29	6	1.58	1.28	24	6	2.83	2.94	23	6	1.58	2.58	30	13	1.62	1.36
	POST		5	1.70	1.48		4	5.38	4.37		6	1.00	1.38		13	1.73	1.68
10	PRE	25	6	3.42	2.11	32	5	5.90	0.92	26	6	2.50	2.24	31	8	2.19	2.48
	POST		6	6.25	7.47		6	3.67	2.32		5	2.50	1.87		11	3.86	2.99
11	PRE	21	6	1.50	1.10	28	5	2.50	2.34	27	6	4.25	3.72	22	13	4.15	5.83
	POST		6	1.75	2.14		6	4.00	1.79		6	3.58	4.62		15	2.83	3.26
12	PRE	27	6	2.92	2.06	22	6	1.33	1.17	28	6	1.00	0.84	21	15	2.50	2.31
	POST		6	3.08	3.41		5	4.50	7.85		6	3.17	3.54		15	1.57	3.07
TREATMENT EFFECT	PRE			2.34	0.61			2.89	1.30			2.73	1.34			3.01	1.30
	POST			3.23	1.71			4.16	1.44			3.12	1.48			2.80	1.31

TABLE E-15

Question-Generating Test, Paper-and-Pencil Measure (Number of Requests for Rationale)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\overline{X}$	SD	CLASS	N	$\overline{X}$	SD	CLASS	N	$\overline{X}$	SD	CLASS	N	$\overline{X}$	SD
1	PRE	28	6	0.00	0.00	21	5	0.70	1.56	22	6	0.50	0.84	27	11	0.32	0.90
	POST		6	0.50	0.55		5	0.00	0.00		6	0.17	0.41		11	0.64	1.03
2	PRE	32	6	1.00	1.45	25	5	0.00	0.00	31	6	0.00	0.00	26	15	0.00	0.00
	POST		6	1.67	1.84		5	0.20	0.45		6	0.50	0.84		15	0.30	0.80
3	PRE	24	6	0.33	0.52	29	5	0.17	0.41	30	6	0.00	0.00	23	13	1.08	1.92
	POST		6	0.92	1.62		5	0.00	0.00		5	0.10	0.22		12	1.17	1.60
4	PRE	22	6	1.17	2.40	27	6	0.42	0.66	21	6	0.25	0.42	28	9	0.17	0.35
	POST		6	0.67	0.98		6	0.25	0.61		6	0.67	0.82		9	0.56	0.88
5	PRE	23	6	1.92	1.69	30	6	0.42	1.02	24	6	0.33	0.82	29	14	0.29	0.75
	POST		6	1.25	1.67		6	1.00	2.00		6	0.75	0.88		14	0.14	0.53
6	PRE	30	6	0.00	0.00	23	6	0.58	0.66	29	6	0.00	0.00	24	13	0.08	0.28
	POST		4	0.00	0.00		5	0.20	0.27		5	0.20	0.45		14	0.18	0.42
7	PRE	31	6	0.17	0.41	26	6	0.00	0.00	25	6	0.33	0.52	32	9	0.39	0.78
	POST		4	0.00	0.00		6	0.33	0.52		6	0.50	0.84		8	0.50	0.76
8	PRE	26	6	0.25	0.61	31	5	0.00	0.00	32	6	0.08	0.20	25	13	0.00	0.00
	POST		6	0.00	0.00		5	0.10	0.22		6	0.33	0.82		12	0.17	0.58
9	PRE	29	6	0.00	0.00	24	6	0.00	0.00	23	6	0.33	0.52	30	13	0.08	0.28
	POST		5	0.40	0.55		4	1.12	1.65		6	0.50	0.78		13	0.08	0.28
10	PRE	25	6	0.17	0.41	32	6	0.50	0.84	26	6	0.42	1.02	31	8	0.06	0.18
	POST		6	0.33	0.82		6	0.83	0.98		5	0.60	0.89		11	0.14	0.32
11	PRE	21	6	0.50	1.00	28	5	0.00	0.00	27	6	0.08	0.20	22	13	0.15	0.32
	POST		6	0.17	0.41		6	0.75	1.84		6	0.08	0.20		15	0.73	1.39
12	PRE	27	6	0.08	0.20	22	6	0.58	1.20	28	6	0.33	0.82	21	15	0.23	0.50
	POST		6	0.75	1.04		5	1.30	1.48		6	0.58	1.43		15	0.20	0.78
TREATMENT EFFECT	PRE			0.46	0.60			0.28	0.28			0.22	0.18			0.23	0.29
	POST			0.55	0.52			0.51	0.46			0.41	0.23			0.40	0.33

TABLE E-16

Question-Generating Test, Paper-and-Pencil Measure (Quality Rating)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	3.18	0.37	21	5	3.56	0.74	22	6	3.08	0.66	27	11	2.76	0.43
	POST		6	3.05	0.67		5	2.86	0.35		6	2.95	0.28		11	2.98	0.39
2	PRE	32	6	3.17	0.46	25	5	3.14	0.73	31	6	2.58	0.36	26	15	2.77	0.58
	POST		6	3.10	0.70		5	3.00	0.49		6	2.82	0.54		15	2.73	0.75
3	PRE	24	6	2.80	0.96	29	6	2.47	0.56	30	6	3.12	0.44	23	13	3.07	0.34
	POST		6	3.32	0.58		5	2.92	0.30		5	2.72	0.34		12	3.21	0.58
4	PRE	22	6	3.32	0.59	27	6	2.67	0.43	21	6	3.38	0.45	28	9	2.82	0.83
	POST		6	2.90	0.51		6	3.08	0.62		6	3.00	0.62		9	3.11	0.70
5	PRE	23	6	2.97	0.59	30	6	2.80	0.37	24	6	2.40	0.87	29	14	2.53	0.77
	POST		6	2.58	1.37		6	2.53	0.56		6	3.05	0.87		14	2.86	0.56
6	PRE	30	6	3.02	0.33	23	6	3.13	0.38	29	6	2.77	0.52	24	13	2.71	0.55
	POST		4	2.93	0.71		5	3.46	0.34		5	2.86	0.34		14	2.81	0.51
7	PRE	31	6	2.58	1.19	26	6	3.10	0.57	25	6	2.67	1.02	32	9	2.97	0.60
	POST		4	2.95	0.54		6	2.78	0.43		6	2.65	0.69		8	2.99	0.31
8	PRE	26	6	2.43	0.82	31	5	2.66	0.42	32	6	3.17	0.37	25	13	3.12	1.00
	POST		6	2.18	0.69		5	3.00	0.31		6	3.20	0.40		12	2.92	0.61
9	PRE	29	6	2.80	0.27	24	6	3.10	0.90	23	6	2.73	0.34	30	13	2.94	0.42
	POST		5	3.04	0.21		4	2.88	0.73		6	2.33	1.22		13	2.95	0.58
10	PRE	25	6	3.47	0.26	32	6	3.18	0.55	26	6	3.07	0.71	31	8	2.81	0.60
	POST		6	3.33	0.64		6	3.02	0.49		5	2.60	0.97		11	3.07	0.64
11	PRE	21	6	3.43	0.75	28	5	3.40	0.75	27	6	2.30	1.15	22	13	3.25	0.53
	POST		6	3.00	0.38		6	3.32	0.46		6	2.80	1.44		15	2.85	0.47
12	PRE	27	6	2.70	0.29	22	6	2.75	0.27	28	6	2.42	1.39	21	15	0.53	0.93
	POST		6	2.90	0.63		5	2.98	0.45		6	3.38	0.38		15	2.79	0.78
TREATMENT EFFECT	PRE			2.98	0.33			3.00	0.33			2.80	0.35			2.94	0.29
	POST			2.94	0.31			2.98	0.24			2.86	0.28			2.93	0.14

TABLE E-17

Question-Generating Test, Oral Measure (Number of Nonpertinent Questions)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	0.00	0.00	21	6	0.08	0.20	22	6	0.17	0.41	27	12	0.38	0.53
	POST		6	0.00	0.00		5	0.00	0.00		6	0.00	0.00		11	0.14	0.32
2	PRE	32	4	0.00	0.00	25	5	0.00	0.00	31	4	0.00	0.00	26	13	0.31	0.63
	POST		5	0.00	0.00		6	0.83	1.60		6	0.67	0.82		13	0.12	0.30
3	PRE	24	6	0.00	0.00	29	5	0.00	0.00	30	6	0.17	0.41	23	14	0.18	0.37
	POST		5	0.00	0.00		5	0.00	0.00		6	0.00	0.00		13	0.12	0.22
4	PRE	22	6	0.33	0.61	27	6	0.00	0.00	21	6	0.08	0.20	28	9	0.39	0.65
	POST		5	0.00	0.00		6	0.17	0.41		6	0.00	0.00		7	0.21	0.39
5	PRE	23	6	0.33	0.82	30	6	0.25	0.61	24	6	0.00	0.00	29	11	0.04	0.15
	POST		6	0.08	0.20		6	0.42	0.80		6	0.00	0.00		13	0.08	0.28
6	PRE	30	6	0.00	0.00	23	6	0.08	0.20	29	6	0.25	0.42	24	12	0.30	0.45
	POST		6	0.00	0.00		5	0.20	0.45		5	0.10	0.22		14	0.04	0.13
7	PRE	31	4	0.00	0.00	26	5	0.50	1.12	25	5	0.30	0.67	32	7	0.07	0.19
	POST		6	0.50	0.77		6	0.83	0.20		6	0.42	0.58		9	0.06	0.17
8	PRE	26	5	0.10	0.22	31	5	0.30	0.67	32	5	0.00	0.00	25	8	0.00	0.00
	POST		6	0.00	0.00		5	0.10	0.23		5	0.00	0.00		11	0.05	0.15
9	PRE	29	6	0.00	0.00	24	6	0.25	0.61	23	4	0.13	0.25	30	12	0.04	0.14
	POST		6	0.00	0.00		6	0.08	0.20		6	0.00	0.00		12	0.08	0.29
10	PRE	25	5	0.00	0.00	32	5	1.20	2.68	26	6	0.00	0.00	31	10	0.45	1.01
	POST		6	0.08	0.20		6	0.33	0.52		6	0.00	0.00		9	0.22	0.51
11	PRE	21	4	0.38	0.75	28	6	0.42	0.80	27	6	0.00	0.00	22	14	0.00	0.00
	POST		5	0.00	0.00		6	0.00	0.00		6	0.17	0.41		15	0.33	0.62
12	PRE	27	6	0.33	0.82	22	6	0.00	0.00	28	6	0.17	0.41	21	14	0.25	0.47
	POST		6	0.08	0.20		6	0.00	0.00		6	0.00	0.00		14	0.25	0.58
TREATMENT EFFECT	PRE			0.12	0.16			0.26	0.34			0.10	0.11			0.20	0.16
	POST			0.06	0.14			0.18	0.24			0.11	0.21			0.14	0.10

TABLE E-18

Question-Generating Test, Oral Measure (Number of Pertinent Questions)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD
1	PRE	28	6	1.75	1.25	21	6	1.75	1.78	22	6	1.92	1.86	27	12	1.33	1.28
	POST		6	1.75	1.66		5	2.90	2.19		6	2.17	0.75		11	1.86	1.25
2	PRE	32	4	1.50	0.58	25	5	0.90	0.74	31	4	1.00	1.41	26	13	0.77	1.59
	POST		5	1.70	1.30		6	2.08	1.36		6	1.50	1.05		13	1.47	1.33
3	PRE	24	6	1.08	1.43	29	5	1.00	1.41	30	6	0.83	0.75	23	14	2.28	2.47
	POST		5	1.50	1.50		5	2.10	0.42		6	1.42	0.80		13	2.92	2.63
4	PRE	22	6	2.33	2.06	27	6	0.75	1.40	21	6	0.33	0.52	28	9	1.00	0.90
	POST		5	3.20	2.51		6	1.17	1.17		6	0.92	0.80		7	2.07	1.24
5	PRE	23	6	0.58	0.92	30	6	1.00	1.26	24	6	0.33	0.52	29	11	0.82	0.90
	POST		6	1.33	1.37		6	1.50	1.05		6	1.75	1.54		13	0.77	1.01
6	PRE	30	6	1.08	1.56	23	6	0.58	0.80	29	6	1.00	0.71	24	12	0.88	0.74
	POST		6	0.67	0.82		5	0.80	0.84		5	2.20	0.84		14	1.78	1.66
7	PRE	31	4	1.25	1.26	26	5	0.90	1.34	25	5	0.70	0.97	32	7	1.14	1.07
	POST		6	1.50	1.10		6	1.50	1.22		6	2.00	0.71		9	2.28	1.99
8	PRE	26	5	0.50	0.87	31	5	1.70	1.10	32	5	0.60	0.55	25	8	0.94	0.94
	POST		6	1.75	0.99		5	2.20	1.35		5	0.80	0.84		11	1.32	1.06
9	PRE	29	6	0.67	0.82	24	6	0.67	0.82	23	4	0.38	0.75	30	12	0.71	1.21
	POST		6	1.83	0.52		6	1.33	1.72		6	2.33	3.03		12	1.33	1.13
10	PRE	25	5	2.00	1.62	32	5	1.42	1.67	26	6	0.42	1.02	31	10	0.55	0.96
	POST		6	3.33	1.60		6	3.08	1.43		6	1.33	1.21		9	1.22	1.92
11	PRE	21	4	0.75	0.96	28	6	1.00	0.84	27	6	1.50	1.05	22	14	1.21	1.31
	POST		5	1.90	0.74		6	2.50	0.63		6	1.25	1.08		15	1.57	1.22
12	PRE	27	6	0.83	0.98	22	6	0.83	1.33	28	6	0.50	0.84	21	14	1.18	1.93
	POST		6	1.75	0.99		6	1.25	1.40		6	1.08	1.02		14	1.14	1.15
TREATMENT EFFECT	PRE			1.19	0.59			1.04	0.38			0.79	0.50			1.06	0.45
	POST			1.85	0.74			1.87	0.72			1.56	0.52			1.64	0.58

TABLE E-19

Question-Generating Test, Oral Measure (Quality Rating)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD
1	PRE	28	6	1.03	0.58	21	6	1.05	0.90	22	6	0.77	0.73	27	12	0.85	0.74
	POST		6	0.95	0.50		5	1.36	0.34		6	1.53	0.33		11	1.02	0.54
2	PRE	32	4	1.80	0.40	25	5	1.10	0.89	31	4	0.58	0.68	26	13	0.40	0.78
	POST		5	1.12	0.70		6	1.30	0.66		6	1.35	1.36		13	1.18	0.78
3	PRE	24	6	0.58	0.65	29	6	0.40	0.55	30	6	0.87	0.70	23	14	0.76	0.60
	POST		5	0.78	0.74		5	1.36	0.38		6	1.10	0.64		13	0.88	0.53
4	PRE	22	6	1.33	0.38	27	6	0.28	0.45	21	6	0.58	0.92	28	9	0.67	0.61
	POST		5	1.30	0.35		6	0.90	0.84		6	0.95	0.61		7	1.33	0.69
5	PRE	23	6	0.50	0.84	30	6	0.68	0.82	24	6	0.33	0.52	29	11	0.70	0.77
	POST		6	0.80	0.65		6	1.03	0.55		6	0.73	0.58		13	0.54	0.66
6	PRE	30	6	0.82	1.02	23	6	0.50	0.77	29	6	0.83	0.52	24	12	1.02	0.78
	POST		6	0.75	0.88		5	0.60	0.55		5	1.26	0.43		14	0.96	0.45
7	PRE	31	4	0.85	0.60	26	5	0.48	0.82	25	5	0.56	0.88	32	7	1.33	0.92
	POST		6	0.95	0.58		6	1.02	0.55		6	1.32	0.32		9	1.22	0.49
8	PRE	26	5	0.70	1.30	31	5	1.64	1.56	32	5	1.20	1.10	25	8	0.72	0.62
	POST		6	0.92	0.47		5	1.08	0.65		5	0.90	0.89		11	1.17	0.86
9	PRE	29	6	0.83	0.98	24	6	0.63	0.76	23	4	0.25	0.50	30	12	0.43	0.72
	POST		6	1.55	0.74		6	0.87	0.85		6	0.73	0.58		12	0.80	0.61
10	PRE	25	5	0.16	1.10	32	5	1.54	2.60	26	6	0.30	0.73	31	10	0.44	0.75
	POST		6	1.30	0.32		6	1.30	0.27		6	0.87	0.70		9	1.34	2.59
11	PRE	21	4	0.50	0.71	28	6	1.03	0.84	27	6	1.08	0.60	22	14	0.86	0.82
	POST		5	1.40	0.26		6	1.55	0.73		6	0.73	0.66		15	1.05	0.73
12	PRE	27	6	0.50	0.55	22	6	0.33	0.52	28	6	0.37	0.57	21	14	0.73	0.83
	POST		6	1.00	0.52		6	0.80	0.94		6	1.12	0.88		14	0.93	0.79
TREATMENT EFFECT	PRE			0.92	0.44			0.80	0.46			0.64	0.31			0.74	0.26
	POST			1.07	0.26			1.10	0.28			1.05	0.27			1.03	0.23

TABLE E-20

Word Association Scale (Attitude Toward Ecology)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD
1	PRE	28	6	58.67	18.95	21	4	57.50	6.86	22	6	58.83	12.58	27	12	62.00	7.27
	POST		6	68.83	2.86		5	62.80	5.17		6	66.50	4.04		12	66.92	5.37
2	PRE	32	6	57.67	6.92	25	5	65.40	5.22	31	6	52.33	20.27	26	15	61.93	8.17
	POST		6	62.67	7.20		6	65.33	4.18		5	69.20	1.30		14	66.57	8.87
3	PRE	24	6	59.50	8.34	29	6	59.83	6.74	30	6	61.17	8.64	23	12	61.50	6.75
	POST		6	58.33	8.85		5	52.80	16.66		6	68.33	2.25		13	59.38	15.55
4	PRE	22	6	59.83	15.16	27	6	59.67	9.20	21	5	45.80	8.17	28	9	55.78	7.74
	POST		5	65.80	8.84		6	69.00	1.55		6	59.00	8.62		9	56.00	14.46
5	PRE	23	5	62.40	8.08	30	6	64.00	6.20	24	6	59.00	12.07	29	14	55.07	11.28
	POST		5	65.00	9.03		6	64.17	7.05		6	63.83	7.30		14	59.07	12.61
6	PRE	30	6	63.50	5.09	23	6	61.17	8.40	29	6	64.67	7.94	24	13	61.23	6.72
	POST		5	69.00	1.41		5	65.60	4.04		5	65.40	5.50		14	63.64	9.82
7	PRE	31	6	61.00	7.72	26	6	60.00	9.74	25	4	68.50	1.73	32	9	63.78	5.09
	POST		6	60.50	10.29		6	67.67	3.83		6	67.83	4.02		7	69.14	2.27
8	PRE	26	6	58.83	12.76	31	5	51.80	9.63	32	6	62.17	5.56	25	8	63.50	6.32
	POST		6	56.50	23.53		6	61.67	12.91		6	69.50	1.22		13	66.54	7.12
9	PRE	29	6	53.83	8.42	24	6	63.33	9.58	23	5	55.00	10.32	30	12	55.75	10.67
	POST		6	47.33	21.11		6	56.00	16.40		6	67.33	2.73		13	55.92	17.69
10	PRE	25	5	66.20	3.56	32	6	56.50	14.39	26	6	57.00	14.83	31	9	52.22	7.48
	POST		6	66.67	6.06		5	60.80	11.21		6	53.67	22.77		8	49.38	17.48
11	PRE	21	6	53.50	8.87	28	6	59.17	7.98	27	6	55.67	15.69	22	13	58.62	9.12
	POST		5	68.20	2.68		6	66.00	3.85		6	61.50	9.09		14	65.71	6.39
12	PRE	27	6	60.67	11.72	22	6	56.83	18.69	28	6	63.00	11.49	21	15	53.73	10.45
	POST		6	61.00	9.94		6	64.33	4.76		6	62.00	9.12		15	64.67	7.77
TREATMENT EFFECT	PRE			59.63	3.64			59.60	3.72			58.59	6.04			58.76	4.06
	POST			62.48	6.32			63.01	4.69			64.51	4.76			61.91	5.94

TABLE E-21

Word Association Scale (Attitude Toward Balance of Nature)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	57.50	8.38	21	4	55.50	3.70	22	6	52.50	12.99	27	12	55.83	7.69
	POST		6	69.00	2.45		5	61.60	3.65		6	61.17	2.48		12	59.08	8.63
2	PRE	32	6	58.83	7.68	25	5	62.20	2.17	31	6	54.83	15.60	26	15	57.20	10.63
	POST		6	59.50	3.73		6	60.83	6.11		5	63.60	4.51		14	57.14	12.13
3	PRE	24	6	55.50	6.89	29	6	58.83	4.45	30	6	56.83	7.33	23	12	59.42	7.84
	POST		6	56.67	7.23		5	56.00	6.52		6	62.83	4.35		13	57.85	13.86
4	PRE	22	6	54.17	5.56	27	6	52.[illegible]7	8.49	21	5	49.80	8.17	28	9	53.11	8.74
	POST		5	61.00	8.22		6	59.0[illegible]	6.57		6	58.17	8.47		9	55.33	11.30
5	PRE	23	5	53.80	5.36	30	6	58.33	7.06	24	6	61.00	4.77	29	14	56.00	8.49
	POST		5	57.00	9.57		6	60.50	4.46		6	63.00	5.40		14	55.14	13.86
6	PRE	30	6	63.33	5.28	23	6	51.83	10.68	29	6	64.67	6.19	24	13	53.92	5.44
	POST		5	65.20	6.72		5	64.40	3.65		5	65.00	6.20		14	56.86	9.00
7	PRE	31	6	50.17	8.47	26	6	53.00	7.48	25	4	59.00	12.25	32	9	54.89	9.12
	POST		6	48.17	24.85		6	59.50	12.11		6	65.17	7.33		7	59.86	9.92
8	PRE	26	6	54.00	7.35	31	5	53.60	11.00	32	6	55.67	4.63	25	8	56.63	5.95
	POST		6	52.83	9.02		6	54.00	11.37		6	62.33	4.89		13	59.15	9.20
9	PRE	29	6	54.67	6.02	24	6	52.50	17.18	23	5	57.20	5.36	30	12	52.83	8.57
	POST		6	50.67	11.84		6	49.33	13.00		6	61.83	8.09		13	54.23	11.81
10	PRE	25	5	61.60	6.99	32	6	57.83	5.98	26	6	59.17	7.78	31	9	50.00	7.30
	POST		6	60.83	7.81		5	57.60	10.60		6	60.17	6.27		8	57.25	11.65
11	PRE	21	6	51.83	8.80	28	6	56.00	6.90	27	6	56.00	8.74	22	13	55.38	9.13
	POST		5	66.60	4.56		6	58.83	5.81		6	60.67	7.47		14	60.14	7.85
12	PRE	27	6	55.17	10.57	22	6	56.83	6.87	28	6	58.17	10.42	21	15	56.73	7.11
	POST		6	59.50	11.09		6	63.67	3.92		6	61.00	6.63		15	57.13	9.00
TREATMENT EFFECT	PRE			55.88	3.83			55.72	3.22			57.07	3.86			55.16	2.45
	POST			58.91	6.31			59.40	4.60			61.41	3.89			57.43	1.89

TABLE E-22

Word Association Scale (Attitude Toward Wolves)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	52.67	8.12	21	4	51.00	10.36	22	6	54.00	7.32	27	12	50.17	12.82
	POST		6	60.67	7.37		5	54.20	4.02		6	60.17	7.57		12	56.92	9.96
2	PRE	32	6	50.00	8.65	25	5	44.20	7.73	31	6	46.83	8.13	26	15	52.07	8.25
	POST		6	52.50	8.17		6	53.33	9.07		5	61.00	5.48		14	51.86	14.74
3	PRE	24	6	46.50	9.07	29	6	46.33	3.39	30	6	47.67	4.76	23	12	50.17	6.32
	POST		6	54.33	11.91		5	48.60	7.02		6	50.33	6.65		13	54.38	13.18
4	PRE	22	6	53.00	4.47	27	6	50.17	12.50	21	5	50.00	4.00	28	9	50.11	7.69
	POST		5	61.20	7.01		6	54.33	8.78		6	53.17	3.92		9	50.56	7.75
5	PRE	23	5	52.60	9.71	30	6	52.83	8.57	24	6	45.67	6.12	29	14	45.14	10.83
	POST		5	58.40	7.64		6	55.67	9.61		6	55.83	11.05		14	54.50	11.74
6	PRE	30	6	47.17	17.88	23	6	49.83	8.23	29	6	51.67	8.26	24	13	44.15	10.24
	POST		5	61.40	5.64		5	53.40	10.14		5	64.00	3.87		14	52.14	12.16
7	PRE	31	6	44.50	7.34	26	6	51.00	5.80	25	4	61.00	3.46	32	9	46.78	12.76
	POST		6	51.83	9.87		6	63.50	10.31		6	59.00	6.13		7	50.71	8.44
8	PRE	26	6	46.83	7.55	31	5	46.20	8.61	32	6	51.00	4.43	25	8	52.25	6.96
	POST		6	56.50	9.52		6	58.83	9.33		6	57.33	6.31		13	55.77	9.50
9	PRE	29	6	46.67	13.34	24	6	46.33	5.89	23	5	51.40	10.97	30	12	47.50	8.48
	POST		6	51.00	12.16		6	56.83	11.20		6	55.00	9.76		13	51.38	11.29
10	PRE	25	5	51.60	3.85	32	6	55.17	9.89	26	6	51.00	7.59	31	9	46.33	9.91
	POST		6	63.83	6.08		5	59.00	9.22		6	60.00	10.12		8	46.88	12.03
11	PRE	21	6	47.17	6.91	28	6	49.17	7.08	27	6	59.17	6.08	22	13	51.62	8.24
	POST		5	60.00	11.64		6	54.00	4.03		6	64.67	5.43		14	50.14	11.04
12	PRE	27	6	56.50	7.39	22	6	46.17	5.34	28	6	46.50	15.48	21	15	50.87	10.84
	POST		6	59.33	7.17		6	54.17	9.33		6	55.83	11.13		15	52.53	10.68
TREATMENT EFFECT	PRE			49.60	3.64			49.03	3.24			50.20	3.80			48.92	2.81
	POST			57.58	4.26			55.49	3.73			58.02	4.26			52.31	2.75

TABLE E-23

Word Association Scale (Attitude Toward Air Pollution)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD
1	PRE	28	6	61.17	5.15	21	4	60.75	4.79	22	6	60.83	4.66	27	12	59.25	5.48
	POST		6	60.17	3.37		5	60.20	2.49		6	60.50	4.61		12	59.75	6.25
2	PRE	32	6	57.17	4.58	25	5	60.80	3.63	31	6	53.50	14.18	26	15	61.47	2.92
	POST		6	59.17	2.32		6	62.00	5.93		5	62.80	2.68		14	60.57	6.62
3	PRE	24	6	60.67	10.01	29	6	60.33	3.83	30	6	59.17	3.71	23	12	58.08	3.37
	POST		6	63.17	5.42		5	59.80	2.68		6	60.00	4.90		13	57.62	10.14
4	PRE	22	6	61.33	5.32	27	6	59.33	2.42	21	5	58.20	3.49	28	9	58.56	7.81
	POST		6	61.33	9.33		6	57.33	3.27		6	60.00	4.52		9	62.89	3.22
5	PRE	23	5	57.40	1.95	30	6	62.50	5.28	24	6	60.83	6.01	29	14	56.00	7.05
	POST		5	58.40	0.85		6	57.33	1.68		6	59.50	5.28		14	57.50	6.30
6	PRE	30	6	60.50	2.81	23	6	59.50	2.51	29	6	60.16	3.37	24	13	63.00	5.99
	POST		5	61.80	3.49		5	59.80	2.68		5	59.80	4.02		14	62.07	4.46
7	PRE	31	6	60.17	2.71	25	6	62.00	5.06	25	4	61.00	3.46	32	9	62.00	2.78
	POST		6	64.00	5.02		6	55.00	16.86		6	61.00	5.02		7	64.00	4.90
8	PRE	26	6	62.17	4.22	31	5	60.40	2.61	32	6	58.83	10.53	25	8	62.38	4.60
	POST		6	61.33	8.45		6	58.33	8.45		6	59.67	5.68		13	59.46	10.21
9	PRE	29	6	60.00	6.48	24	6	59.33	2.80	23	5	58.20	4.02	30	12	58.42	3.75
	POST		6	58.33	3.88		6	54.17	7.39		6	59.50	5.28		13	59.77	4.00
10	PRE	25	5	61.60	3.29	32	6	63.17	5.31	26	6	60.33	3.44	31	9	56.44	5.22
	POST		6	59.00	2.45		5	62.80	3.42		6	59.67	2.42		8	57.75	7.57
11	PRE	21	6	51.17	25.79	28	6	59.17	9.11	27	6	57.50	0.84	22	13	59.38	3.80
	POST		5	58.00	0.00		6	63.00	5.18		6	57.16	5.53		14	60.43	4.43
12	PRE	27	6	57.17	9.26	22	6	59.83	2.56	28	6	57.67	2.42	21	15	61.13	3.92
	POST		6	61.00	3.79		6	60.33	3.67		6	55.50	6.68		15	61.53	3.76
TREATMENT EFFECT	PRE			59.08	2.97			60.59	1.33			58.85	2.11			59.67	2.31
	POST			60.21	1.78			59.22	2.84			59.59	1.81			60.27	2.09

TABLE E-24

Word Association Scale (Attitude Toward Alligators)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD
1	PRE	28	6	46.00	5.62	21	4	50.00	6.06	22	6	45.00	8.29	27	12	39.83	16.48
	POST		6	55.33	5.82		5	45.20	8.23		6	56.00	10.04		12	47.83	11.02
2	PRE	32	6	38.17	9.06	25	5	36.80	14.60	31	6	45.17	7.73	26	15	41.87	16.83
	POST		6	45.50	8.14		6	46.00	5.22		5	52.00	4.12		14	58.14	11.42
3	PRE	24	6	40.50	12.24	29	6	40.50	4.18	30	6	37.17	4.79	23	12	43.67	8.05
	POST		6	50.67	14.19		5	44.60	7.57		6	47.50	7.31		13	48.46	13.80
4	PRE	22	6	43.83	11.67	27	6	39.17	15.50	21	5	43.00	4.00	28	9	43.00	6.48
	POST		5	43.40	10.55		6	44.67	12.29		6	48.83	2.23		9	46.89	7.25
5	PRE	23	5	47.60	7.44	30	6	48.17	6.88	24	6	44.33	8.07	29	14	38.71	7.33
	POST		5	50.60	4.67		6	50.00	11.44		6	59.67	8.09		14	45.64	13.67
6	PRE	30	6	43.83	16.35	23	6	40.83	8.68	29	6	43.33	5.85	24	13	42.46	9.10
	POST		5	53.00	11.58		5	53.40	11.26		5	57.00	7.71		14	46.86	8.54
7	PRE	31	6	38.33	8.64	26	6	45.50	6.78	25	4	35.50	4.65	32	9	40.89	13.96
	POST		6	52.00	5.18		6	55.50	16.49		6	53.00	8.17		7	40.14	12.09
8	PRE	26	6	41.67	10.39	31	5	38.60	7.96	32	6	43.17	9.60	25	8	43.62	10.56
	POST		6	54.17	8.45		6	50.33	6.47		6	46.50	13.88		13	58.77	7.17
9	PRE	29	6	32.83	9.02	24	6	36.50	10.58	23	5	46.20	14.10	30	12	39.67	8.79
	POST		6	44.83	14.36		6	49.67	10.48		6	50.83	9.11		13	33.92	10.68
10	PRE	25	5	46.00	7.64	32	6	45.33	7.34	26	6	39.00	12.93	31	9	43.22	9.72
	POST		6	53.50	6.80		5	52.80	8.90		6	56.33	11.33		8	47.25	11.62
11	PRE	21	6	41.33	10.60	28	6	42.00	5.97	27	6	49.83	11.30	22	13	41.62	7.26
	POST		5	51.80	5.31		6	51.17	4.75		6	56.67	6.53		14	45.29	8.20
12	PRE	27	6	45.83	8.26	22	6	39.67	7.53	28	6	39.00	13.30	21	15	40.87	12.78
	POST		6	55.17	10.50		6	49.00	7.73		6	50.50	8.80		15	48.27	12.44
TREATMENT EFFECT	PRE			42.16	4.26			41.92	4.38			42.56	4.13			41.61	1.65
	POST			51.66	3.40			49.36	3.62			52.73	4.48			46.78	2.85

TABLE E-25

Word Association Scale (Attitude Toward Water Pollution)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	62.00	4.90	21	4	60.50	10.72	22	6	62.83	5.88	27	12	59.92	8.61
	POST		6	60.00	3.10		5	59.20	1.79		6	60.50	4.81		12	59.92	6.64
2	PRE	32	6	57.33	5.99	25	5	60.40	3.91	31	6	57.83	3.82	26	15	61.67	3.15
	POST		6	59.67	2.66		6	63.50	4.85		5	64.00	4.24		14	58.57	7.24
3	PRE	24	6	60.67	10.01	29	6	60.17	4.12	30	6	59.50	3.67	23	12	60.75	4.31
	POST		6	63.17	5.42		5	54.00	10.70		6	58.00	7.59		13	56.15	13.15
4	PRE	22	6	58.50	2.26	27	6	57.50	0.84	21	5	58.80	2.95	28	9	57.56	7.20
	POST		5	58.40	0.89		6	57.50	1.22		6	60.00	6.20		9	60.11	7.70
5	PRE	23	5	62.40	8.08	30	6	62.00	4.90	24	6	62.00	3.10	29	14	56.93	7.13
	POST		5	58.80	1.79		6	58.33	0.82		6	57.50	8.78		14	56.00	7.80
6	PRE	30	6	61.00	3.35	23	6	59.67	5.24	29	6	60.50	3.99	24	13	60.15	4.00
	POST		5	60.40	3.29		5	59.00	2.24		5	59.40	2.61		14	61.21	4.37
7	PRE	31	6	60.33	2.58	26	6	60.50	5.50	25	4	58.75	3.77	32	9	11.67	3.32
	POST		6	63.33	4.55		6	55.00	16.86		6	61.00	5.02		9	3.78	1.99
8	PRE	26	6	63.17	5.31	31	5	61.40	3.97	32	6	63.17	5.42	25	8	62.00	4.17
	POST		6	61.33	7.37		6	58.83	7.96		6	63.33	5.50		13	60.15	9.66
9	PRE	29	6	61.00	5.02	24	6	61.00	3.52	23	5	60.00	3.67	30	12	57.58	5.47
	POST		6	56.83	9.60		6	53.17	11.21		6	56.83	2.86		13	58.23	3.06
10	PRE	25	5	61.60	3.29	32	6	60.00	5.18	26	6	60.33	4.76	31	9	54.44	6.73
	POST		6	59.00	2.45		5	62.20	5.02		6	60.67	2.80		8	56.88	11.72
11	PRE	21	6	60.67	2.50	28	6	59.83	9.00	27	6	58.00	3.03	22	13	60.00	2.92
	POST		5	58.00	2.12		6	63.00	5.90		6	52.67	14.40		14	60.93	4.84
12	PRE	27	6	58.67	11.71	22	6	58.83	3.87	28	6	55.50	2.59	21	15	60.33	5.69
	POST		6	60.00	2.45		6	59.33	3.98		6	55.00	6.51		15	59.67	7.11
TREATMENT EFFECT	PRE			60.19	1.83			60.15	1.17			59.77	2.21			59.45	2.34
	POST			59.91	1.96			58.59	3.34			59.07	3.28			59.15	1.99

TABLE E-26

Gall-Crown Discussion Attitude Scale (Attitude toward Thought Questions)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD
1	PRE	28	6	28.00	5.18	21	5	31.40	6.35	22	6	28.17	4.49	27	11	30.09	2.84
	DELAY		6	29.33	3.39		3	30.00	4.58		5	30.20	3.49		12	31.08	6.68
2	PRE	32	6	26.17	6.85	25	5	31.00	2.74	31	6	25.50	3.27	26	14	29.00	5.88
	DELAY		6	28.50	8.96		5	31.40	5.27		6	28.83	4.07		15	29.40	5.37
3	PRE	24	4	32.25	5.38	29	6	30.67	3.44	30	6	29.50	4.37	23	12	29.33	5.07
	DELAY		4	30.25	5.12		5	31.80	4.27		6	30.33	9.00		14	27.50	8.39
4	PRE	22	6	25.00	6.87	27	6	28.00	6.03	21	6	28.50	5.54	28	9	28.44	4.80
	DELAY		6	30.67	5.96		6	28.00	4.86		4	28.25	5.06		8	29.00	5.55
5	PRE	23	6	30.50	6.22	30	6	27.67	6.15	24	6	29.00	5.48	29	14	28.00	5.45
	DELAY		6	34.50	6.35		6	30.00	4.00		6	33.83	8.59		14	30.43	6.39
6	PRE	30	6	28.50	3.27	23	5	33.80	4.02	29	6	25.83	2.48	24	12	27.92	4.46
	DELAY		6	31.67	5.72		6	27.33	6.41		6	32.00	3.85		13	30.23	4.40
7	PRE	31	6	25.67	3.08	26	6	29.67	4.46	25	6	32.50	4.68	32	9	30.22	5.80
	DELAY		6	24.83	9.24		6	35.17	5.27		6	35.00	4.05		8	32.38	7.13
8	PRE	26	6	27.00	4.90	31	6	27.00	5.33	32	6	26.50	3.90	25	13	33.15	4.95
	DELAY		6	26.50	3.21		5	35.00	4.90		6	30.17	5.67		12	33.50	6.17
9	PRE	29	6	27.00	4.56	24	6	24.67	4.59	23	6	30.83	6.01	30	13	31.08	3.62
	DELAY		6	28.67	4.41		6	26.17	6.14		6	30.33	8.19		12	29.25	5.03
10	PRE	25	6	29.83	5.07	32	6	30.17	7.17	26	6	22.67	4.55	31	9	29.00	4.03
	DELAY		5	30.80	6.26		6	32.50	6.32		6	25.83	10.36		10	27.50	9.20
11	PRE	21	6	33.00	7.07	28	5	26.60	4.88	27	5	25.20	5.45	22	14	27.14	6.04
	DELAY		6	34.50	6.41		5	28.80	5.80		6	27.83	11.00		14	27.36	6.42
12	PRE	27	6	28.00	2.58	22	6	28.17	8.54	28	5	27.40	4.22	21	15	29.07	5.11
	DELAY		6	30.00	4.60		6	26.33	7.79		5	29.40	3.58		13	27.92	3.38
TREATMENT EFFECT	PRE			28.41	2.54			29.06	2.51			27.63	2.70			29.37	1.61
	DELAY			30.18	2.65			30.21	3.06			30.16	2.53			29.62	1.99

Gall-Crown Discussion Attitude Scale (Attitude toward Discussions)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	PRE	28	6	54.33	8.38	21	5	55.80	8.53	22	6	54.50	4.64	27	11	55.45	6.90
	DELAY		6	55.67	8.94		3	49.00	11.36		5	53.40	5.37		12	63.33	8.95
2	PRE	32	6	52.83	12.95	25	5	54.20	6.10	31	6	51.50	7.01	26	14	53.14	6.90
	DELAY		6	53.00	10.54		5	59.40	7.54		6	48.17	7.28		15	52.67	7.87
3	PRE	24	4	57.50	8.10	29	6	52.83	4.26	30	6	58.50	6.98	23	12	57.50	9.76
	DELAY		4	59.25	3.59		5	60.60	7.09		6	57.00	9.76		14	49.43	13.26
4	PRE	22	6	52.83	8.40	27	6	51.83	10.59	21	6	53.67	7.66	28	9	49.33	10.19
	DELAY		6	56.17	5.95		6	54.17	8.66		4	51.25	5.38		8	49.13	7.18
5	PRE	23	6	59.00	8.48	30	6	60.17	5.71	24	6	57.33	9.16	29	14	57.00	5.95
	DELAY		6	60.33	10.17		6	57.83	5.42		6	63.33	11.55		14	57.71	8.77
6	PRE	30	6	63.17	3.97	23	5	60.80	5.45	29	6	56.67	5.75	24	12	52.83	7.32
	DELAY		6	61.00	10.81		6	47.17	11.05		6	57.67	4.68		13	55.00	7.06
7	PRE	31	6	53.83	8.06	26	6	55.00	6.23	25	6	58.33	7.55	32	9	60.00	6.18
	DELAY		6	44.17	18.99		6	60.33	8.76		6	60.67	6.47		8	60.00	8.69
8	PRE	26	6	53.83	8.13	31	6	50.83	5.42	32	6	50.00	10.77	25	13	57.23	8.79
	DELAY		6	54.17	6.64		5	59.80	6.38		6	50.33	10.48		12	59.67	10.08
9	PRE	29	6	54.17	4.79	24	6	58.67	7.09	23	6	54.83	9.66	30	13	58.46	6.24
	DELAY		6	51.17	11.77		6	55.33	7.09		6	55.00	12.00		12	54.00	9.57
10	PRE	25	6	58.00	4.20	32	6	53.83	8.61	26	6	48.50	8.74	31	9	52.11	7.82
	DELAY		5	59.40	6.69		6	57.50	10.50		6	48.33	11.78		10	50.50	13.57
11	PRE	21	6	57.50	4.85	28	5	53.40	3.65	27	5	46.00	10.44	22	14	51.86	8.54
	DELAY		6	68.00	7.04		5	54.60	3.21		6	52.00	14.13		14	50.29	11.19
12	PRE	27	6	50.67	7.97	22	6	52.17	8.33	28	5	50.40	4.62	21	15	52.00	12.56
	DELAY		6	51.33	6.06		6	52.50	7.97		5	52.80	9.36		13	52.23	7.20
TREATMENT EFFECT	PRE			55.64	3.46			54.96	3.29	—		53.35	4.07			54.74	3.29
	DELAY			56.13	6.09			55.68	4.43			54.16	4.74			53.91	3.86

TABLE E-28

Ecology Unit Opinions (Attitude Toward Peers)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD	CLASS	N	X̄	SD
1	POST	28	6	17.17	1.83	21	5	15.20	3.83	22	6	17.50	1.05	27	11	16.73	1.68
2	POST	32	6	17.83	2.32	25	6	17.33	1.86	31	6	17.17	2.04	26	15	16.40	3.72
3	POST	24	5	16.40	1.52	29	5	18.40	1.52	30	6	15.50	2.07	23	13	14.92	3.45
4	POST	22	6	17.83	1.94	27	6	15.50	1.87	21	6	16.00	3.29	28	9	14.67	2.18
5	POST	23	5	15.80	2.95	30	5	18.60	2.61	24	6	17.67	2.73	29	13	17.46	2.50
6	POST	30	5	18.20	1.30	23	5	16.80	3.56	29	4	17.75	1.89	24	13	14.92	3.99
7	POST	31	5	14.60	2.97	26	6	17.33	1.63	25	6	19.33	0.82	32	9	16.67	3.00
8	POST	26	6	15.67	3.50	31	5	18.20	2.68	32	6	18.50	1.64	25	12	17.25	2.26
9	POST	29	6	15.00	3.22	24	5	15.20	4.92	23	6	17.50	1.76	30	13	15.38	3.40
10	POST	25	6	16.67	3.20	32	6	17.50	1.87	26	6	16.67	2.66	31	11	14.09	3.08
11	POST	21	6	19.83	0.41	28	6	17.00	2.00	27	6	16.83	4.12	22	15	15.40	3.33
12	POST	27	6	17.50	2.34	22	6	18.33	2.07	28	6	14.33	3.26	21	15	16.13	2.29
TREATMENT EFFECT	POST			16.87	1.49			17.12	1.24			17.06	1.34			15.83	1.09

TABLE E-29

Ecology Unit Opinions (Attitude Toward Ecology Teacher)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	POST	28	6	61.33	3.44	21	5	58.00	4.85	22	6	61.83	3.12	27	11	59.54	6.07
2	POST	32	6	60.17	2.99	25	6	56.33	5.82	31	6	60.67	1.97	26	15	56.47	11.09
3	POST	24	5	56.60	10.26	29	5	60.40	3.36	30	6	54.50	7.04	23	13	56.92	8.58
4	POST	22	6	59.83	5.34	27	6	60.67	2.50	21	6	53.17	9.41	28	9	53.44	7.40
5	POST	23	5	57.20	7.26	30	5	58.40	6.23	24	6	61.17	2.64	29	13	61.00	3.56
6	POST	30	5	59.80	5.67	23	5	60.20	4.97	29	4	59.25	3.50	24	13	56.15	7.45
7	POST	31	5	57.80	6.61	26	6	61.33	2.34	25	6	63.17	1.17	32	9	58.67	8.54
8	POST	26	6	55.83	9.11	31	5	55.60	15.08	32	6	62.50	2.07	25	12	61.50	4.80
9	POST	29	6	51.00	11.01	24	5	52.80	9.34	23	6	49.50	18.15	30	13	53.69	7.49
10	POST	25	6	59.83	4.12	32	6	57.33	10.65	26	6	58.00	5.18	31	11	52.54	13.85
11	POST	21	6	61.83	2.32	28	6	58.67	7.03	27	6	57.67	10.65	22	15	57.60	7.67
12	POST	27	6	55.83	11.00	22	6	57.33	7.61	28	6	51.00	10.02	21	15	58.40	5.77
TREATMENT POST EFFECT				58.09	3.04			58.09	2.44			57.70	4.63			57.16	2.89

TABLE E-30

Ecology Unit Opinions (Attitude Toward Ecology Curriculum) Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	POST	28	6	33.67	2.16	21	5	31.60	6.11	22	6	32.17	3.25	27	11	33.18	3.03
2	POST	32	6	34.33	1.63	25	6	32.83	2.99	31	6	32.33	2.58	26	15	32.53	5.87
3	POST	24	5	33.60	2.19	29	5	34.00	1.00	30	6	30.33	5.32	23	13	31.62	6.18
4	POST	22	6	32.17	2.86	27	6	33.50	3.88	21	6	30.33	6.53	28	9	29.33	4.64
5	POST	23	5	31.80	4.92	30	5	32.00	5.15	24	6	33.17	6.01	29	13	31.77	5.58
6	POST	30	5	34.20	2.05	23	5	29.80	5.85	29	4	31.25	4.11	24	13	31.00	4.56
7	POST	31	5	31.80	4.09	26	6	34.00	2.00	25	6	35.33	1.21	32	9	33.22	4.46
8	POST	26	6	31.67	4.03	31	5	33.20	3.11	32	6	34.00	2.45	25	12	32.92	6.08
9	POST	29	6	24.00	8.92	24	5	26.80	9.04	23	6	26.50	10.25	30	13	30.15	5.43
10	POST	25	6	35.67	0.52	32	6	32.33	5.82	26	6	33.00	3.35	31	11	28.73	8.87
11	POST	21	6	35.17	0.75	28	6	34.33	2.42	27	6	58.00	3.03	22	15	31.40	5.84
12	POST	27	6	29.50	6.72	22	6	30.00	4.65	28	6	28.00	6.16	21	15	33.47	3.31
TREATMENT EFFECT	POST			32.29	3.14			32.03	2.21			31.49	2.47			31.60	1.57

TABLE E-31

Ecology Discussion Attitude Scale (Attitude toward Thought Questions)
Study II Descriptive Statistics

ECOLOGY TEACHER		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	POST	28	6	35.67	3.08	21	5	35.20	6.76	22	6	36.50	5.47
2	POST	32	6	34.67	4.37	25	6	33.83	4.36	31	6	30.83	4.17
3	POST	24	5	31.80	7.40	29	5	34.60	4.93	30	6	30.50	9.35
4	POST	22	6	32.83	6.24	27	6	32.50	6.89	21	6	33.00	7.59
5	POST	23	6	34.67	5.24	30	6	36.17	2.32	24	6	35.17	9.37
6	POST	30	5	36.20	4.76	23	5	25.80	15.02	29	5	32.40	3.51
7	POST	31	6	29.17	9.26	26	6	35.00	4.56	25	6	39.00	4.15
8	POST	26	6	33.33	5.57	31	6	35.50	7.12	32	6	32.00	4.73
9	POST	29	6	25.83	3.19	24	6	22.83	9.13	23	6	31.50	10.65
10	POST	25	6	36.67	6.56	32	5	33.60	6.58	26	6	30.67	6.74
11	POST	21	5	35.60	6.69	28	6	31.50	2.26	27	6	31.17	7.81
12	POST	27	6	32.67	3.83	22	6	31.33	6.71	28	6	31.33	4.18
TREATMENT EFFECT	POST			33.25	3.16			32.32	4.09			32.92	2.66

TABLE E-32

Ecology Discussion Attitude Scale (Attitude toward Discussion)
Study II Descriptive Statistics

ECOLOGY TEACHER ID		25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II			
		CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	POST	28	6	64.33	6.68	21	5	60.60	12.42	22	6	65.67	8.76
2	POST	32	6	62.33	4.08	25	6	62.67	5.72	31	6	58.00	4.20
3	POST	24	5	55.60	8.26	29	5	56.00	9.35	30	6	57.17	11.48
4	POST	22	6	58.33	7.97	27	6	63.17	7.81	21	6	59.50	9.42
5	POST	23	6	63.00	7.35	30	6	62.67	7.97	24	6	63.67	9.56
6	POST	30	5	62.00	6.32	23	5	53.40	3.21	29	5	58.00	6.52
7	POST	31	6	56.33	11.81	26	6	63.17	6.74	25	6	67.00	4.73
8	POST	26	6	59.50	7.42	31	6	64.50	9.33	32	6	60.00	8.50
9	POST	29	6	47.00	9.10	24	6	49.33	13.63	23	6	55.83	15.85
10	POST	25	6	66.00	5.40	32	5	59.40	8.96	26	6	47.50	25.69
11	POST	21	5	69.60	5.08	28	6	59.17	3.49	27	6	59.33	10.11
12	POST	27	6	56.83	5.53	22	6	60.00	9.72	28	6	54.83	8.06
TREATMENT EFFECT	POST			60.07	5.88			59.50	4.54			58.87	5.19

TABLE E-33

Ecology Art Project Scale (Attitude toward Art Projects)
Study II Descriptive Statistics

ECOLOGY TEACHER		ART ACTIVITY TREATMENT II			
ID		CLASS	N	$\bar{X}$	SD
1	POST	27	12	69.00	7.14
2	POST	26	14	61.93	9.59
3	POST	23	13	61.62	15.42
4	POST	28	9	58.67	9.27
5	POST	29	13	63.92	8.98
6	POST	24	12	61.92	8.24
7	POST	32	7	67.43	6.50
8	POST	25	12	72.17	2.59
9	POST	30	13	59.69	10.51
10	POST	31	11	58.27	10.62
11	POST	22	15	63.00	10.34
12	POST	21	13	62.77	9.32
TREATMENT EFFECT	POST			63.36	4.21

TABLE E-34

Number of Treatment Sessions Attended
Study II Descriptive Statistics

ECOLOGY TEACHER	25% HIGHER COGNITIVE QUESTIONS TREATMENT II				50% HIGHER COGNITIVE QUESTIONS TREATMENT II				75% HIGHER COGNITIVE QUESTIONS TREATMENT II				ART ACTIVITY TREATMENT II			
ID	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD	CLASS	N	$\bar{X}$	SD
1	28	6	9.17	0.98	21	5	8.60	1.34	22	6	8.17	2.23	27	12	9.83	0.39
2	32	6	10.00	0.00	25	6	9.67	0.82	31	6	9.83	0.41	26	14	10.00	0.00
3	24	6	9.50	0.84	29	6	8.67	1.21	30	6	9.33	1.21	23	14	10.00	0.00
4	22	6	9.33	1.21	27	6	8.00	3.63	21	6	9.33	0.82	28	9	8.56	1.51
5	23	6	9.50	0.55	30	6	9.67	0.82	24	6	9.67	0.82	29	14	9.78	0.42
6	30	6	8.50	3.21	23	6	9.33	1.03	29	6	9.17	1.33	24	11	9.27	1.27
7	31	6	9.17	0.75	26	6	9.33	0.52	25	6	9.50	0.55	32	9	9.44	0.88
8	26	6	9.50	0.84	31	6	9.33	1.21	32	6	9.50	0.55	25	12	9.67	0.89
9	29	5	9.60	0.55	24	6	9.83	0.41	23	6	9.17	0.75	30	13	9.92	0.28
10	25	6	9.17	0.98	32	6	9.50	0.55	26	6	8.50	1.52	31	11	9.00	2.72
11	21	6	9.83	0.41	28	6	8.50	2.51	27	6	9.00	1.55	22	15	9.73	0.59
12	27	6	9.17	1.17	22	6	9.83	0.41	28	6	8.83	1.60	21	15	8.73	1.49
TREATMENT EFFECT			9.37	0.39			9.18	0.60			9.16	0.48			9.49	0.50